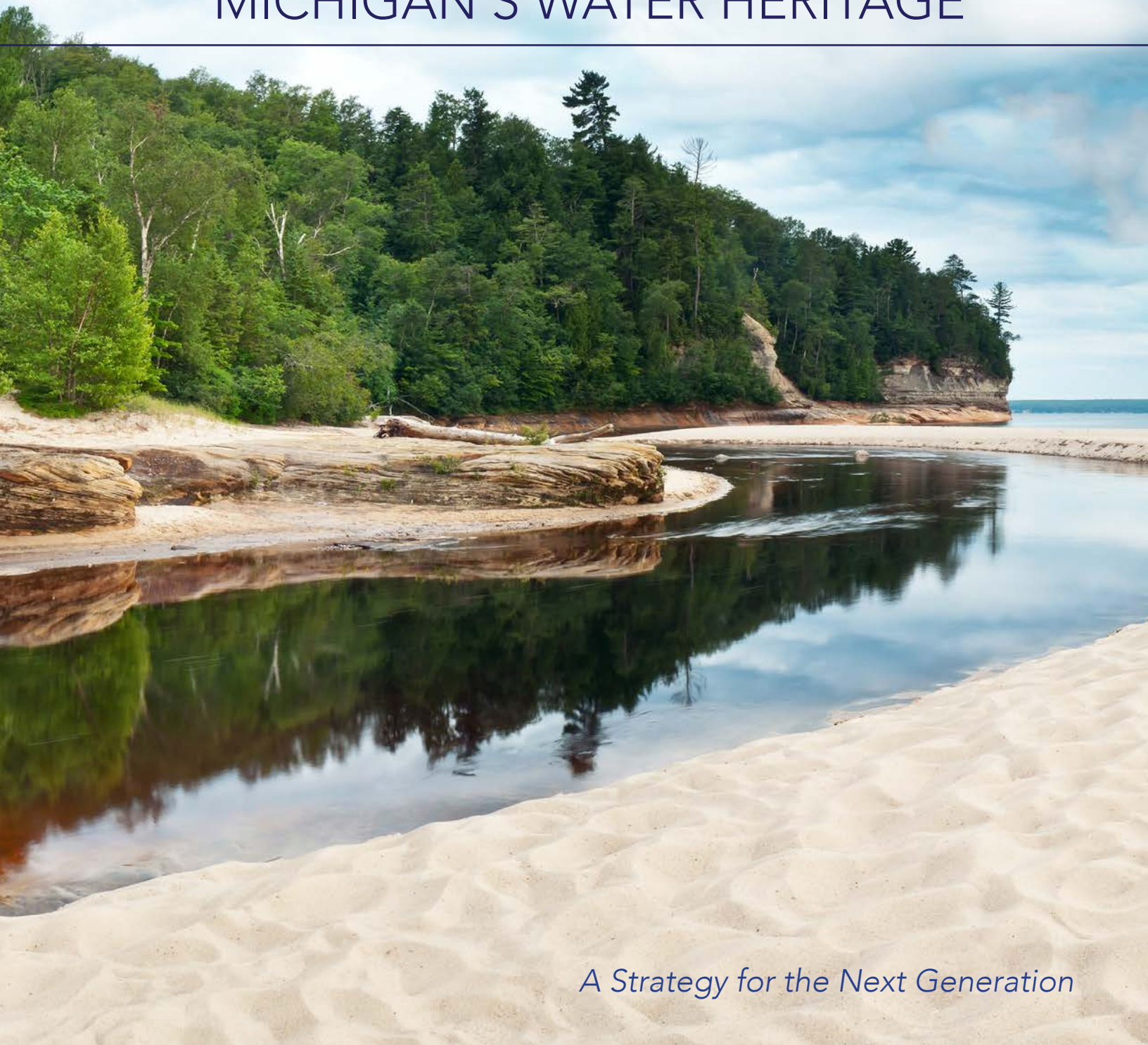


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SUSTAINING

MICHIGAN'S WATER HERITAGE



A Strategy for the Next Generation

- DRAFT -

Prepared by:

Michigan Office of the Great Lakes, *in Collaboration with*
Michigan Department of Environmental Quality
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Vision

Michigan's water resources
support a healthy
environment, healthy citizens,
vibrant communities and
sustainable economies.

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Introduction

Water defines Michigan. It is deeply rooted in the state's culture, heritage and economy. With more than 11,000 inland lakes, 76,000 miles of rivers, 6.5 million acres of wetlands and more than 3,200 miles of freshwater coastline—the longest in the world—leveraging the power and presence of this treasured natural resource and ensuring its long-term sustainability are critical to advancing Michigan's prosperity.

Clean, abundant freshwater is a competitive advantage for Michigan and it is growing in importance. At the beginning of 2015, the World Economic Forum in its global risk report identified water crisis as the number one risk influencing the global economy.¹ Michigan's water resources are vitally important for agricultural production, irrigation, drinking water, electric utilities, mining, manufacturing and water supply to lakes and streams that support valuable fish, waterfowl and wildlife populations. Michigan's abundant water assets and research capabilities, in addition to its highly-skilled talent, economic development expertise, innovation and invention, and powerful tourism and business marketing brand, are pivotal drivers for attracting business creation and investment.

With this abundance comes a deep sense of responsibility and stewardship - but Michigan has not always treated its water with a sense of care. Today, the state is slowly returning to a level of aquatic health in many waterways and lakes necessary to fully support diverse fish and wildlife and meaningful recreation in many communities. Through longstanding public and private partnerships and tremendous investment of time and resources, communities are making significant progress in cleaning up legacy contamination.

But that is just the beginning. The ability to achieve Michigan's vision for its water resources depends on a strategic, collaborative ecosystem-based plan that monitors the health and condition of our water resources, invests in water-related infrastructure, uses water more thoughtfully and efficiently to grow sustainable economies, reconnects communities to water, and fosters a water ethic and culture of stewardship.

Michigan's Water Strategy - An Ecosystems Approach

The forthcoming Water Strategy takes an ecosystem approach, focused on the fact that Michiganders are a part of the ecosystem in which we live and therefore have an effect on the health of our water resources. The Strategy recognizes the core values identified with water are four fold: economic, environmental, social and cultural. All are equally important. Communities across Michigan recognize the value of water quality improvement activities supported through state and federal investments. According to Brookings Institution and Grand Valley State University, restoring water quality and shorelines respectively result in a 3-to-1 and 6.6-to-1 return on investment in the form of increased property values and local economic development and improved ecosystem health and quality of life.

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The value of water is not exclusively economic nor is it solely environmental, though without a healthy environment, human uses are diminished and fish and wildlife perish. Social value is represented as how water forms a basis for activity and time with friends and family, and how these uses create joy and memories. Cultural value is about identity and affinity to place: where we choose to live and why; who and what we identify with; and where our stories, myths and beliefs come from. For Michiganders, water – and especially the Great Lakes – forms a core part of identity and culture.

The approach recognizes that each of these four values needs to be addressed in balance with the others. They temper and mold each other; they exist together and may require compromise, accommodation and limits. This approach is reflected in the Strategy through its goals, outcomes and recommendations.

A Roadmap to Achieve the Vision

The Water Strategy outlines a 30-year vision shaped by a desire for high-quality, accessible water resources protected by and for present and future generations based on the question asked in multiple forums around the state: *“What do you want Michigan and Michigan’s water resources to look like and do over the next generation?”* Throughout the development of the Strategy, Michiganders said they care deeply about the Great Lakes, rivers and inland lakes, groundwater, and water in general. It is this caring that ultimately drives the ability to support, choose, manage and fund the requirements of healthy water. To that end, the Strategy recognizes that decisions made now regarding infrastructure, technology, monitoring and water literacy will set the course for decades.

Great Lakes, Water and Governance

The Great Lakes and Michigan water resources have long been recognized as a valuable resource fundamental to our way of life by federal and provincial governments, tribal nations and the eight states within the basin. The Great Lakes region has long-standing governance and institutional structures, organizations and other formal and informal mechanisms focused on protecting, restoring and maintaining the integrity of this vast water resource. These include the International Joint Commission, Great Lakes Water Quality Agreement, Great Lakes–St. Lawrence River Water Resource Compact Agreement, Council of Great Lakes Governors, Great Lakes Commission, Great Lakes Fishery Commission and many others. As a result, decisions made with regard to Michigan’s water resources are subject to collaboration, consultation, oversight and regulation under a complex framework of regional governance structures and federal, state and tribal laws.

Government-to-government relationships are an important part of the governance landscape in Michigan as recognized by the 2002 Government-to-Government Accord between the state of Michigan and the federally recognized Indian tribes within the state’s borders. For generations, the Indian tribes have resided in the Great Lakes region and

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depended on the Great Lakes and Michigan's inland lakes, rivers, streams and groundwater for their way of life. These water resources provide food, transportation and drinking water, in addition to fulfilling many cultural purposes.

Exploitation of native fisheries, wildlife and forests during Michigan's emergence as the manufacturing center of the nation created great wealth and a high quality of life, but also devastated native fish populations, impacted water quality, and left a complex and costly legacy of contamination. Federal, state, tribal and local regulation and restoration programs have made substantial progress in addressing this legacy. This network of programs and actions has been instrumental in reaching toward the goals of ensuring drinkable, swimmable, and fishable waters as established in Michigan's Natural Resource and Environmental Protection Act, Safe Drinking Water Act, the federal Clean Water Act, and cleanup statutes such as the Environmental Remediation and Leaking Underground Storage Tank Act. In addition to these efforts, recent investments by the federal government through the Great Lakes Restoration Initiative have accelerated efforts to clean up and restore our water resources and fish and wildlife populations, and to improve quality of life in many communities.

Government-to-government relationships, statutes, regulations and management programs all play a critical and complementary role to the actions recommended in the Water Strategy. Driving progress toward the goals and the outcomes will depend on harnessing this complex framework of governance, institutions, and regulations to continue to build durable relationships and collaboration around common interests.

Strategic Action

The Water Strategy charts a course by providing recommendations and identifying strategic actions to:

Protect and Restore Aquatic Ecosystems – Michigan needs more integrated, holistic approaches to managing water on and across the landscape, including groundwater, which support healthy ecological systems and hydrologic integrity at the watershed scale.

Ensure Clean and Safe Waters – Michigan needs to protect and restore water quality to ensure ecosystem function and support current and future human uses of Michigan's surface and groundwater resources.

Create Vibrant Waterfronts – Michigan needs an emphasis on water resources as assets in state, regional and community planning efforts to create vibrant and sustainable communities, a robust recreation and tourism industry, and a thriving environment and economy.

Support Water-Based Recreation – Michigan needs to create greater opportunity for access to water resources through water trails and appropriate public access.

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Promote Water-Based Economies – Michigan needs to collectively build robust multi-sector and multidisciplinary public-private partnerships between business, industry, academia, private capital and government. These partnerships will link ideation, invention and innovation, research and development, capital investment and end users. This approach will bring technologies to the market to better manage and solve water challenges in Michigan and across the globe. Directed research and development to address specific water challenges should provide the basis for forming a new paradigm of collaboration.

Invest in Water Infrastructure – Greater and consistent investments are needed in water-related infrastructure improvements to address aging and deteriorating systems that are now causing water quality issues and public health concerns. The people of Michigan also need to better recognize the connection between investments in water infrastructure systems and the benefits it provides, including delivery of safe drinking water, management of stormwater and wastewater, enhanced recreational opportunities, and healthy ecosystems and economies.

Monitor Water Quality – Michigan needs to develop and fund a coordinated, long-term monitoring strategy to provide baseline and trend information about surface and groundwater quality and quantity. This information is necessary to base decisions and best direct actions and future investments to support healthy people, ecosystems, communities and economies.

Build Governance Tools – Michigan needs to build new models of governance at the local and regional level to address increasingly complex and intractable problems facing Michigan's water resources. Implementation efforts will require not just state agencies, but a wide array of individuals, organizations, businesses, industries and tribal and local governments across the state to continue to build on this multi-stakeholder collaborative approach.

Inspire Stewardship for Clean Water – Most importantly, Michigan residents need greater opportunities to learn about water. Michigan is surrounded by 20 percent of the world's fresh surface water, and with that comes a deep ethical obligation to be good and thoughtful stewards of this global treasure. A shared water ethic will guide Michigan into the future and ensure our children and future generations will have the same or better quality of life than we have today. The durability of this Strategy and ensuring the health of our water resources for generations to come depends on creating a culture of stewardship through lifelong education about water.

We call on all people of Michigan to be thoughtful and engaged stewards of our water resources.

Water Strategy Framework

The Water Strategy is organized around nine goals and outcomes designed to ensure the viability and sustainability of Michigan's water resources over time, while placing Michigan on the path to achieving its water vision in a way that builds economic capacity while sustaining ecological integrity of this crucial resource for future generations.

The Water Strategy includes 62 recommendations that are a set of interconnected ideas to drive a new relationship between Michigan's communities, governments, and residents to solve complex water challenges and create greater opportunities for economic and social well-being. The recommendations are designed to drive performance and behavior change, address barriers and contribute toward achieving the desired outcomes. The ability to achieve the stated goals and outcomes will require both the implementation of recommendations in the Strategy and continued implementation of the entire suite of existing water-related programs and initiatives, some of which are noted in Appendix 3.

The Strategy includes an Implementation Plan (Table 2) comprised of recommendations, a lead actor charged with implementation and an implementation metric to measure progress toward accomplishing the recommendation. A wide host of actors and agents across the state, including governments, tribal nations, nonprofits, industry, businesses, individuals, and local and regional philanthropies will need to be involved. Therefore, the Water Strategy is not a specific action plan only for government, though there are many actions that government can and should take. Rather, it is a strategy for all people of Michigan, believing that together, we can have a positive impact on the future of the state.

Additional recommendations were identified during the development process as important to achieving outcomes but are of lesser priority and are included in Table 3.

Measures of Success

The Strategy includes measures of success intended to examine system response over time as a result of the collective impact of implementation of the Water Strategy recommendations and other efforts already underway by state, federal and local governments and partners to rebuild healthy aquatic systems, clean water and vibrant economies. Achieving success will require integrating planning strategies for water resources with local units of government, unifying plans between the state, regions and local units of governments, and collaborating with stakeholders. Additionally, success will require an integrated process for adapting to new science and understanding of complex issues, evaluating progress, and making course corrections necessary to achieve outcomes.

Table 1: Water Strategy Priority Recommendations and Measures of Success

Table 1 highlights 22 key priority recommendations as a subset of the 62 recommendations in the Water Strategy. These recommendations address the most critical and imminent issues facing Michigan's water resources as well as some of Michigan's greatest opportunities to enhance our economy and strengthen the relationship people have to water. Key recommendations were identified based on input received during the development of the Strategy.

Measures of success are included to measure progress toward achieving outcomes as a result of the implementation of all of the Water Strategy recommendations and other efforts already underway by state, federal and local governments and partners.

Protect and Restore Aquatic Ecosystems	Goal 1: Michigan's aquatic ecosystems are healthy and functional.	
	Outcome: Aquatic ecosystems are resilient and diverse	
	Key Recommendations	Measures of Success
	<ul style="list-style-type: none"> Prevent introduction of new AIS and control established populations. Develop a comprehensive strategy to prevent nuisance and harmful blue green algal blooms. Achieve a 40% phosphorus reduction in the western Lake Erie basin. Promote green infrastructure, low impact development and green spaces to rebuild hydrologic integrity and address storm water. 	<ul style="list-style-type: none"> Brook trout are present and thriving with no net loss of cold water habitat due to water withdrawals and habitat manipulations. Sturgeon are considered rehabilitated in 10% of streams targeted for rehabilitation in Michigan's Lake Sturgeon Rehabilitation Strategy. Lake trout are naturally reproducing and supporting wild fish-based fisheries in Lakes Superior, Huron, and Michigan. Appropriate reduction in nuisance and harmful algal blooms. Waters of the state meet Water Quality Standards for being swimmable, fishable and drinkable. Reduction in annual volume of untreated sewage discharges. Reduce the number of designated use impairments due to wet weather discharges.

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Ensure Safe and Clean Water	Goal 2 – Michigan’s water resources are clean and safe.	
	Outcome: Surface and groundwater are managed to support sustainable human uses and ecological function.	
	<div>Key Recommendations</div> <ul style="list-style-type: none">Protect drinking and source water from contamination and spills.Pass a statewide sanitary code and inspection requirements.Secure long-term funding to accelerate clean-up of contaminated sites.Establish priorities and address emerging pollutants of concern.	<div>Measures of Success</div> <ul style="list-style-type: none">100 percent of the population has safe drinking water with no reported violations of health-based standards.No drinking water advisories, beach closures or aquatic life impairments due to harmful algal blooms.No designated use impairments due to failing on-site wastewater systems.No new designated use impairments due to emerging pollutants of concern
Create Vibrant Waterfronts	Goal 3 – Michigan communities use water as a strategic asset for community and economic development.	
	Outcome: Economic and community development plans and efforts fully leverage water assets to create great places to live, work and play.	
	<div>Key Recommendations</div> <ul style="list-style-type: none">Leverage water resource assets at state, regional and local level to create sustainable economic opportunities.Support investments in commercial harbors and ports and address long-term maritime infrastructure needs.	<div>Measures of Success</div> <ul style="list-style-type: none">All community and economic development plans integrate water resource assets.
Support Water-based Recreation	Goal 4 – Michigan’s water resources support quality natural resources, recreation and cultural opportunities.	
	Outcome: Waters of the state are world renowned for recreational pursuits such as hunting, fishing, boating and swimming.	
	<div>Key Recommendations</div> <ul style="list-style-type: none">Expand real-time monitoring of beaches.Prioritize investments in recreational harbors to address long-term infrastructure needs.Develop and implement a water trails system.	<div>Measures of Success</div> <ul style="list-style-type: none">30% increase in water-based recreation and tourism.90% of the population has convenient access to swimmable and fishable water.By 2020, 100% of the state’s recreation harbors will have an infrastructure asset management plan to ensure a safe harbor.
Promote Water-based Economies	Goal 5 – Michigan has a strategic focus on water technology and innovation to grow sustainable water-based economies.	
	Outcome: Policies and innovative technologies are developed and adopted to grow and promote sustainable water-based economies.	
	<div>Key Recommendations</div> <ul style="list-style-type: none">Accelerate water technologies to solve water problems using an entrepreneurial business-led initiative.Establish voluntary water efficiency targets for all major water dependent sectors.	<div>Measures of Success</div> <ul style="list-style-type: none">Michigan is recognized as a place to invest and locate a business because of its support for sustainable water technologies, water conservation, and high quality of life.Increase in percentage of economic output per gallon of water utilized.

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	<ul style="list-style-type: none">Develop a water conservation and reuse strategy.	<ul style="list-style-type: none">Increase in water sector employment and earnings at the statewide and county level.			
Invest in Water Infrastructure	Goal 6 - Michigan invests in infrastructure and supports funding to maintain clean water and healthy aquatic ecosystems.				
	Outcome: People support investment of both public and private funding of Michigan water resources.				
	<table><tr><th>Key Recommendations</th><th>Measures of Success</th></tr><tr><td><ul style="list-style-type: none">Establish a long-term Water Fund to achieve Water Strategy goals including water infrastructure management.</td><td><ul style="list-style-type: none">Sustained funding is in place to implement the Water Strategy and achieve the goals of the Strategy.Outcome-based asset management plans are implemented and progress is achieved toward true cost of service for water utilities.</td></tr></table>	Key Recommendations	Measures of Success	<ul style="list-style-type: none">Establish a long-term Water Fund to achieve Water Strategy goals including water infrastructure management.	<ul style="list-style-type: none">Sustained funding is in place to implement the Water Strategy and achieve the goals of the Strategy.Outcome-based asset management plans are implemented and progress is achieved toward true cost of service for water utilities.
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Monitor Water Quality	Goal 7 - Michigan has integrated outcome-based monitoring systems that support critical water-based decisions.				
	Outcome: Monitoring systems are in place at a scale and frequency to ensure water quality and quantity are maintained to support diverse uses and values.				
	<table><tr><th>Key Recommendations</th><th>Measures of Success</th></tr><tr><td><ul style="list-style-type: none">Implement a pilot water resource decision framework.Support groundwater and surface water monitoring.</td><td><ul style="list-style-type: none">Achieve a net stabilization of groundwater depth across the state.Long-term monitoring strategies are being implemented.</td></tr></table>	Key Recommendations	Measures of Success	<ul style="list-style-type: none">Implement a pilot water resource decision framework.Support groundwater and surface water monitoring.	<ul style="list-style-type: none">Achieve a net stabilization of groundwater depth across the state.Long-term monitoring strategies are being implemented.
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Build Governance Tools	Goal 8 - Michigan has the governance tools to address water challenges and provide clean water and healthy aquatic ecosystems.				
	Outcome: Policies, organizational and institutional structures are in place to achieve goals and outcomes of the strategy.				
	<table><tr><th>Key Recommendations</th><th>Measures of Success</th></tr><tr><td><ul style="list-style-type: none">Create an integrated system for managing water at the local level to achieve water quality and quantity outcomes.Retain full authority to continue to manage Michigan’s water resources.</td><td><ul style="list-style-type: none">By 2030, achieve a 40% reduction in number of designated uses or impaired waters.</td></tr></table>	Key Recommendations	Measures of Success	<ul style="list-style-type: none">Create an integrated system for managing water at the local level to achieve water quality and quantity outcomes.Retain full authority to continue to manage Michigan’s water resources.	<ul style="list-style-type: none">By 2030, achieve a 40% reduction in number of designated uses or impaired waters.
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Inspire Stewardship for Clean Water	Goal 9 – Michigan citizens are stewards of clean water and healthy aquatic ecosystems.				
	Outcome: Individuals and communities understand their responsibility for and make informed and responsible decisions regarding water resources.				
	<table><tr><th>Key Recommendations</th><th>Measures of Success</th></tr><tr><td><ul style="list-style-type: none">Integrate water literacy into state of Michigan curriculum standards.</td><td><ul style="list-style-type: none">Increase the number of citizens with knowledge and understanding of water literacy principles.Michigan citizens support funding for water and implementation of the Water Strategy.</td></tr></table>	Key Recommendations	Measures of Success	<ul style="list-style-type: none">Integrate water literacy into state of Michigan curriculum standards.	<ul style="list-style-type: none">Increase the number of citizens with knowledge and understanding of water literacy principles.Michigan citizens support funding for water and implementation of the Water Strategy.
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PROTECT

and restore aquatic ecosystems

Chapter 1: Protect and Restore Aquatic Ecosystems

Goal: Michigan's aquatic ecosystems are healthy and functional.

Outcome: Aquatic ecosystems are resilient and diverse.

Healthy, functional ecosystems purify air and water, provide habitat for fish and wildlife, support natural resource-based economies, serve as buffers from flooding, and support recreational activities. All long-term, sustainable uses of water depend on intact ecological and hydrologic systems. Ecosystems link living organisms with the non-living components of their environment like the water, soil, and air. While the Strategy focuses on the water component of ecosystems, it recognizes that changes in the make up or distribution of organisms, disturbances on the land or in the air also impact water and that the management of water on and across the landscape or hydrology directly affects those systems.

For example, the introduction of aquatic invasive species (AIS) in the Great Lakes region has been a major challenge to the resiliency and diversity of aquatic ecosystems. The presence of invasive species combined with nutrient runoff can have devastating impacts on fisheries and other aquatic life, disrupt the ecology of lakes and streams as well as contribute to nuisance aquatic plant growth and algae blooms. In a few areas of the Great Lakes, nuisance algal growths have been associated with botulism outbreaks, "muck" (organic debris) washing up on beaches, and impacts to drinking water systems. Some nuisance algal growths have also been characterized as harmful algal blooms (HABs).

The practice of moving water off the landscape as quickly as possible has resulted in both positive and negative consequences. Since the mid-1800s, Michigan has developed more than 35,000 miles of public drains, serving more than 17 million acres of agricultural and urban lands and roadways. These drains provide benefits by removing excess storm water, preventing damage from flooding, improving soil productivity, and enabling residential and commercial development. However, these extensive drainage systems were designed without consideration of the long-term consequences of modifying the natural hydrology.

In addition, other hydrologic modifications like storm drains and extensive impervious surfaces contribute to less infiltration and increased surface water runoff and flow, resulting in increasingly "flashy" streams. These cause stream bank erosion and increase sediment loads, transporting nutrients that impair aquatic life. The loss of infiltration can reduce vital recharge of aquifers and reduce base flow to streams. In rural areas, infiltration to deeper depths is interrupted by tile drains designed to conduct water away

from fields. These changes can pollute receiving waters, impact aquatic life that depends on groundwater-fed streams during summer months, and affect human groundwater use.²

Changing weather events will also require changes in water management. While Michigan's future climate is unclear, variability in precipitation from year-to-year is large. Despite lower than average lake levels during the past decade, total annual precipitation has increased in the Great Lakes basin by 4.5 inches from 1915 to 2004, with 4.2 of those inches occurring from 1955 to 2004.³ The intensity of extreme weather events leads to more rapid runoff, greater flashiness in streams, sediment loadings and flooding events. Current infrastructure capacity was not designed to effectively handle this increase.

The Water Strategy focuses on reducing threats to aquatic ecosystems and implementing watershed-based approaches to restore hydrologic integrity and improve aquatic ecosystem resiliency. Holistic watershed-based approaches that slow the movement of water across the landscape, increase infiltration capacity, reduce erosion, sediment, nutrient flow and wastewater discharges, and increase aquifer recharge are needed for long-term preservation of Michigan's hydrology.

Prevent Introduction of and Manage Aquatic Invasive Species

Since the 1800s, more than 182 nonindigenous aquatic organisms, including animals, plants, bacteria and viruses, have colonized the Great Lakes ecosystem, forever altering its ecology. The introduction of AIS into the Great Lakes and inland waters has caused significant damage to the state's natural resources and many human uses.

Impacts include Eurasian water milfoil clogging inland lakes, the devastating effects of sea lamprey on fish communities, round gobies taking bait, and water fleas snagging fishing lines. Of particular note, invasive mussels have disrupted the energy flow, nutrient cycling and food web which has resulted in changes in fish communities and have contributed to nuisance aquatic plant growth and algae blooms. The intensive filtering activities of zebra and quagga mussels have greatly increased water clarity, allowing the long filamentous algae known as *Cladophora*, as well as other types of algae, to grow to nuisance levels in areas where it previously did not occur. When *Cladophora* dies and breaks loose, it creates conditions ripe for the production of the botulinum toxin in Great Lakes sediments by creating the very low oxygen conditions required by Type E botulism spores to become active. Type E botulism outbreaks have resulted in the death of waterbirds and fish kills. While there are no management options currently available for broad-scale control of zebra and quagga mussels, there are ongoing efforts to evaluate the efficacy of new management options such as the biocide Zequanox, a naturally occurring bacteria being tested to specifically control zebra and quagga mussel populations.

Michigan has led the region for decades in focusing on prevention of new introductions and minimizing impacts of established invasive species. To combat the introduction of new AIS and minimizing the impacts of established ones, Michigan developed the second state AIS

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management plan in 1996, later updating it in 2013. It provides a comprehensive strategy outlining new actions and enhancing existing efforts to prevent and control AIS in Michigan waters, including continued support for separation of the Great Lakes and Mississippi watersheds. In addition, the Michigan Department of Natural Resource's Fisheries Division Strategic Plan, *Charting the Course: Fisheries Division's Framework for Managing Aquatic Resources*, provides specific actions to support healthy aquatic ecosystems and sustainable fish populations. It also provides strategic assessments and tools to inform decision-making. However, more is needed. Long-term mandates for the prevention of new invasive species into the basin will depend on a collaborative approach.

Recommendations

Prevent the introduction of new AIS and control existing AIS populations in accordance with the Michigan Aquatic Invasive Species Management Plan.

Work with other Great Lakes states and provinces to harmonize aquatic invasive species prevention, early detection processes, and response actions across the Great Lakes region.

Accelerate research and solutions to identify mechanisms of food web disruption and changes of nutrient flows in the Great Lakes with a focus on the effects of invasive species.

Reduce Occurrence and Impacts of Harmful and Nuisance Algal Blooms

Nuisance algal blooms are increasingly a problem in the Great Lakes and have been documented in some inland waters. Some algal blooms are dominated by blue-green algae also known as cyanobacteria that produce harmful toxins and these blooms are characterized as harmful algal blooms (HABs) based on concentrations of toxins produced. The most common algal toxins are Microcystin, Anatoxin-a, Cylindrospermopsin, and Saxitoxin. For example, the toxin Microcystin is produced by the cyanobacteria *Microcystis*. HABs occur when Microcystin exceeds the World Health Organization's non-drinking water guideline of 20 ug/l or drinking water criteria of 1 ug/l in water bodies with drinking water intakes. However, state agencies will likely adopt new criteria as additional information becomes available.

The presence of these toxins are known to impact human health and aquatic life can cause closures of drinking water systems and beaches, including a well-publicized HAB in western Lake Erie in 2014 that prompted Toledo officials to shut down the drinking water system and a few areas in Michigan. Health symptoms commonly associated with algal toxin exposure include nausea, skin rashes, gastro-intestinal distress, numbness and fatigue.⁴ These toxins can also kill fish and other aquatic life. The most commonly monitored algal toxin in Michigan is Microcystin; however, MDEQ is evaluating monitoring protocols for other toxins.

Algal blooms are caused by many factors, including excessive inputs of nutrients, usually phosphorus and to a lesser extent nitrogen. Meteorological conditions can also play a role

in determining algal bloom severity and seasonal dynamics. For example, the occurrence and duration of extreme weather events, such as heavy rainfall and droughts, may influence the development of algal blooms by intensifying the magnitude and timing of nutrient delivery from the watershed.⁵ In addition, changes in the food web caused by the introduction of invasive species can change the way nutrients are partitioned in the environment or change environmental conditions enough to trigger algal blooms. Physical factors affecting water temperature, light penetration and water column mixing may also contribute to create potentially favorable conditions for algal blooms.

Addressing agricultural point and nonpoint sources of sediment and nutrients that have been identified as a major source of the pollutants in recent western Lake Erie Basin studies conducted in both Michigan and Ohio is one step to combating HABs. These opportunities include promoting changes in the use of phosphorus through mechanisms like the 4R Program (Right Source, Right Rate, Right Time, Right Place), implementation of the Michigan Agriculture Environmental Assurance Program (MAEAP) suite of practices, restoration of grasslands and wetlands, use of vegetative filter strips, and use of technologies like precision farming and implementing no-till and conservation tillage techniques to reduce run-off.

However, the biggest challenge remains the lack of a comprehensive understanding of the cause of HABs in Michigan's waters. For example, HABs that are capable of producing toxins are not limited to nutrient rich waters and can be found in nutrient poor waters like oligotrophic lakes. It is not possible to tell visually (including via satellite), by taste or by odor whether a bloom is a HAB. Additional work must be done in order for state, federal and local partners to make strategic decisions to determine best possible solutions to address the problem. A strategy to prevent HABs should be developed, involving a broad set of state, federal and local partners and including conducting additional monitoring and data collection to improve the understanding of the cause of HABs and inform models and actions to achieve the desired water quality and public health outcomes.

Recommendations

Develop a comprehensive strategy to prevent nuisance and harmful blue green algal blooms.

Achieve a 40% phosphorus reduction in the western Lake Erie basin.

Develop harmful algal toxin water quality criteria and implement a real-time monitoring strategy for Michigan's Great Lakes drinking water intakes and public recreation locations threatened by harmful algae.

Support the development of a national drinking water advisory or action level target for harmful algal toxins.

Integrate Water Knowledge into Local Land-Use Planning

Land-use planning is inextricably linked to healthy aquatic ecosystems, a clean and available water supply, and protection from natural occurrences that can damage property. In Michigan, decisions about how the land can be used are made at the local level through master planning and zoning ordinances. Communities use these tools to plan and guide the character of the community and influence the local economy.

However, local community and economic development planning is based on political boundaries and jurisdictions, not along watershed boundaries. To be effective, these planning tools should consider activities that adversely affect water quality and quantity, such as extreme weather events, throughout their watershed and incorporate best management practices into transportation, infrastructure and zoning regulations and other community development planning to minimize impacts on local water resources.

Recommendations

Incorporate planning for wet weather extremes and increased variability into state, regional, and community planning.

Provide technical assistance and develop technical tools and training programs for communities, local officials and water stakeholders to inform and improve their water literacy and help them integrate water impacts into local land-use planning and decisions.

Build Resiliency into Riparian Systems

One of the most direct ways to positively influence water quality and aquatic habitat is to restore, create and improve riparian areas. Riparian areas, or land area adjacent to a stream or lake, provide critical ecosystem services and benefits for lakes and rivers, including:

- Reducing runoff by acting as a barrier and protecting against erosion and nonpoint source pollution
- Absorbing contaminants
- Moderating water temperature through shading
- Serving as a greenway corridor for birds, mammals, amphibians and reptiles
- Contributing leaves, woody debris and other organic matter as foundation for the food web and providing in-stream habitat for fish and other aquatic organisms
- Providing pleasing recreational corridors or views

Accelerated erosion and sedimentation problems occur in rivers throughout Michigan as a result of lack of riparian management. In some watersheds, lack of upstream riparian filter strips or buffers results in the need for increased downstream dredging at river mouths for boat access and international shipping. Hardening of the riparian zones, lack of shade due

to deforestation, and a lack of continuity in riparian areas all contribute to increased stream temperatures, resulting in declines of fish and wildlife habitat.

Currently a patchwork of regulations, including watershed management plans, best management practices, state programs and landowner incentives, are used to manage riparian zones. The success of many voluntary programs, however, is contingent on a well-informed and cooperative landowner. To maximize benefits, a more holistic watershed approach is needed for riparian area management. Taking a broad approach starting upstream and working downstream to the mouth of the river can have comprehensive impacts on aquatic ecosystems, international shipping, and river recreation. In addition, the interest in waterfront development combined with the need to decrease management costs (dredging) and reduce impacts of extreme weather events provides an opportunity to better define science-based actions and consciously manage riparian areas throughout Michigan.

Recommendation

Develop tools and guidance related to shoreline and riparian ecology and management and provide necessary technical support and training to municipalities, watershed-based organizations and landowners to achieve full benefits of riparian areas.

Restore Hydrologic Connectivity

Michigan has more than 2,500 dams, the majority of which are nearing or have exceeded their design life. Federal, state and local governments as well as conservation organizations are removing dams that provide little to no natural resource value to reconnect streams and rivers. However, challenges exist including: ownership questions (74 percent of dams are privately owned), financial burdens, social views on dam removal and value of impoundments behind dams. Additionally, careful considerations must be made to prevent the upstream movement of unwanted invasive species and downstream movement of contaminated sediment trapped behind dams.

Despite these challenges, federal, state and locally funded efforts have achieved progress in restoring connectivity. As examples, dam removal and river restoration projects are re-envisioning the role of the Boardman, Cass and Huron Rivers. These restoration efforts create greater opportunity for recreation and economic development by connecting water and place within communities.

Recommendations

Remove or improve dams that are no longer safe or ecologically, economically or socially viable to protect public safety and create healthy connected aquatic systems.

Focus river and stream restoration efforts on addressing small hydrological impediments like culverts to create connectivity and restore stream stability.

Manage Groundwater Withdrawals

Michigan's water resources are vitally important for agricultural production, irrigation, drinking water, electric utilities, mining, manufacturing and water supply to lakes and streams that support valuable fish, waterfowl and wildlife populations. Despite the large volumes of surface and groundwater in Michigan – more than one quadrillion gallons by some estimates – there is growing concern about its use and about groundwater withdrawal effects on environmental function and integrity. Groundwater use and value is increasing, and the state must invest in the information and decision systems to realize groundwater's full value, promote its wise use, and protect its hydrological and ecological integrity.

Groundwater is an important resource for commercial, industrial, domestic, and public supply purposes. Most of Michigan's large groundwater withdrawals, however, are for agricultural irrigation. More than 2,500 high-capacity irrigation groundwater wells have been registered for installation during the past four years. These wells greatly enhance economic development (in particular agricultural productivity), ensure against drought conditions and augment high-value crop production. However, as farmers and others develop more high-capacity irrigation wells, the odds of interfering with nearby domestic wells and surface water systems like rivers and lakes also increase.

Michigan has developed the Michigan's Water Withdrawal Assessment Tool to help the state manage groundwater withdrawals. A new or increased high-capacity well must be evaluated using the groundwater tool before installation. The Groundwater Tool is specifically designed to assess the likelihood of an adverse impact of withdrawals on nearby streams, rivers and fish communities. Michigan's Water Use Advisory Council, established by MDEQ in 2012, completed its assessment of Michigan's water management framework, including the Water Withdrawal Assessment Tool, and issued a series of recommendations to MDEQ in December 2014. The recommendations are now under departmental review and assessment. The development of a robust and effective water management program for the state will be an ongoing, iterative process and the insights and recommendations such as the ones in the council's report will continue to help shape the development of that process.

Recommendation

Refine and improve the water withdrawal assessment process to ensure sustainable use of water resources and that high priority is given to incorporating existing and new data and models to better represent local and regional water resources and surface water/groundwater interactions.

Improve Water Management in Urban Landscapes

In urban areas impervious surfaces like roads, buildings and parking lots prevent rainfall from penetrating the soil. As natural vegetation is removed and these surfaces increase, the

amount of evapotranspiration and groundwater recharge decreases. This causes increased runoff, stream channel erosion, buried river bottoms due to silt and sediment, reduced or lost habitat, and aquatic species decline. Aging infrastructure and ill-managed or improperly managed stormwater runoff also contributes to sewer overflows, affecting water quality, ecological systems, creating human health risks, and negatively impacting the enjoyment of water resources.

As municipalities struggle to address aging infrastructure and capacity issues, opportunities exist to transition away from grey to green infrastructure. Green infrastructure can increase a community's resiliency to severe weather events by increasing infiltration and absorption of water. This reduces flooding risk, decreases surface runoff into lakes and streams, and reduces impacts of aging systems. Many communities are considering developing green infrastructure such as wetlands, bioswales, green spaces and buffer strips, as well as man-made infrastructure like rain gardens. Overcoming barriers to green infrastructure such as limited funding mechanisms, regulatory and permitting requirements, institutional and organizational capacity, and lack of understanding of design and maintenance requirements will be necessary to improve water management and address stormwater.

Recommendations

Provide technical and financial support to communities to plan and implement green infrastructure techniques and low-impact development while preserving natural spaces in the design of new developments, redevelopments and road projects to ensure responsible stormwater management and improve hydrology.

Modernize road and highway planning and infrastructure to effectively accommodate stormwater runoff and infiltration needs, thereby reducing the costs and impacts of flooding.

Enhance financial and technical support of local stakeholder efforts to develop and implement watershed management plans to restore impaired waters, protect high-quality waters, and develop and utilize local water resource assets.

Use existing authority to work with local unit of governments with stormwater discharge or stormwater-related hydrologic impairments in their waterways to establish Phase II stormwater plans for impaired water bodies.

Improve Water Management in Rural Landscapes

Michigan's \$5.5 billion drainage infrastructure sustains some of the most productive agricultural land in the world and became the key component to developing land for residential, commercial, industrial and transportation purposes. However, the historical land changes that led to this productivity, such as the draining of wetlands, dredging and straightening of rivers and streams, converting streams to drains, and deforestation, have resulted in degraded water quality and aquatic ecosystems.

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The agricultural community understands the importance of water resource conservation and is continuously considering new methods for managing water, including restoring hydrology, enhancing soil's capacity to retain and infiltrate rainfall, and allowing for aquifer recharge. New science and technological advancements are also impacting agricultural water management with research in areas such as identifying the most efficient irrigation timing and amounts for crops in dry weather conditions, water reuse for irrigation, and reducing nutrient loss via tile lines.

The federal Agriculture Act of 2014 commonly known as the Farm Bill is also providing resources to enhance conservation practice implementation in Michigan to address nutrients and sediment. Other initiatives are underway such as the newly formed regional and community-led Healthy Waters Working Farms that combines conservation practices and farmland preservation to keep Michigan's rivers and lakes clean while keeping the best farmland working.

It is critical that governments, academia and industry collaborate to develop new tools, processes, and systems to help local officials, landowners, agricultural producers, and others who impact the rural landscape to take actions to improve water resources. The Natural Resource Working Group has concluded that the establishment of collaborative partnerships to support learning and adaptation is needed to foster community-based natural resource management. Engaging the rural community as a whole in deciding what behaviors should change to maintain and improve water quality, and determine what actions would be necessary to encourage behavior change, are necessary to drive performance toward desired outcomes on the landscape.

Recommendation

Eliminate impairments in priority watersheds that have degraded water quality and/or aquatic ecosystems due to nutrient runoff and soil erosion. Engage landowners through a collaborative and adaptive community-based natural resource management process to identify local actions to change behaviors and solutions to achieve those outcomes. Failure to achieve demonstrable outcomes within established timeframes could trigger additional measures.



ENSURE

clean and safe water

Chapter 2: Ensure Clean and Safe Water

Goal: Michigan's water resources are clean and safe.

Outcome: Surface and groundwater are managed to support sustainable human uses and ecosystem function.

Clean, safe water is fundamental to Michigan's economy and to ensuring high-quality places to live, work and play. It is equally fundamental for functioning and sustainable aquatic systems.

Michigan faces complex challenges in addressing water resource issues because of a wide range of historic and ongoing activities such as deposition of mercury, legacy pollutants (i.e. polychlorinated biphenyls (PCBs)), chemical contamination, nonpoint sources of excessive sediment and nutrients (i.e. phosphorous), harmful algal growth, changing climate, urban and rural runoff, hydrologic impairment of rivers and streams, contaminated sediment, and invasive species. All of these things continue to stress drinking water supplies, groundwater resources, aquatic systems, water-based recreation, and local economies.

During the past 100 years, water resource concerns have shifted largely from regulating activities such as effluent pollution and dredge and fill to focus on water resource challenges caused by multiple stressors that require both traditional and new regulatory solutions. Protecting and restoring water quality is critical to ensure ecosystem function while supporting current and future human uses of Michigan's surface and groundwater resources.

Protect Drinking Water Supplies

Ensuring adequate and safe drinking water for all of Michigan's nearly 10 million residents and visitors is essential to protecting public health. The state has more than 10,500 public water systems, of which roughly 8,500 utilize untreated or largely untreated high-quality groundwater sources. In addition, Michigan has more than 1 million private domestic wells, more than any other state in the U.S.

While public water supplies are subject to oversight and frequent inspections to ensure sanitary conditions, individual residential water well owners are responsible for maintenance of their own wells. Construction of private wells is primarily handled at the local level and overseen by a rigorous permitting program. Improper well siting and construction and maintenance, however, are known contributors to drinking water contamination. Broken well caps and contamination sources placed near wells are some of the problems that put drinking water and groundwater at risk. Therefore, planning for appropriate residential and public drinking water well placement, coupled with proper

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well construction by a Michigan-registered drilling contractor, are the foundation for safe and reliable drinking water. In addition, periodic inspections of private drinking water wells are needed to ensure sanitary conditions.

Another risk to Michigan's water resources are the estimated 2 million improperly abandoned wells. These abandoned wells can act as a direct conduit between the surface and underlying aquifers as well as between aquifers. These conduits can result in surface contaminants flowing into private or public drinking water supplies.

The lack of statewide regulations or controls on the installation of closed-loop geothermal borings poses additional risks. Improperly located or constructed closed-loop geothermal borings have the same potential to harm aquifers as improperly abandoned water wells. Many vertical geothermal borings are installed at the same depths as drinking water wells, but have no regulatory oversight to ensure installation does not create a direct conduit for contaminants to reach the aquifer.

In many areas of the state, nitrate contamination is a concern. In Michigan, the U.S. Geological Survey regards nitrate-N levels of more than 2 milligrams/liter in water as a sign that human-related nitrate sources have adversely affected the water. In rural areas, elevated levels of nitrate can be associated with animal manure and agricultural fertilizers. Septic systems can also serve as a source of nitrate contamination, though that risk is minor if the systems are designed and maintained for nitrogen removal and water wells are properly sited, constructed and maintained.

Additionally, businesses and industries generate wastes that can threaten groundwater quality if not handled properly. Groundwater contamination resulting from improper waste disposal and chemical handling threatens public health and the environment, resulting in significant cleanup costs to businesses. In addition, contamination of public water supplies can result in high costs to public water suppliers and taxpayers to provide alternative water or replace contaminated drinking water supplies.

Further, the release of oils, chemicals, salts and polluting materials from human activities and industrial sites can impact water. A majority of these releases can be prevented through regulatory programs, but releases still occur unexpectedly. Appropriate response actions to control, mitigate and remediate these releases are critical to minimize harm to Michigan's surface and groundwater.

Recommendations

Protect drinking and source water areas by:

- *Continuing to ensure remediation activities address the long-term impact on drinking water sources*
- *Identifying and diligently protecting source water protection areas*
- *Assisting well owners with identifying potential water well vulnerabilities*

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- *Focusing resources on contamination sources with the highest potential for causing contamination of drinking water supplies, including chemical storage facilities*
- *Enhancing the drinking water geographic information system database and making information available across MDEQ programs and to local public health department environmental health personnel*
- *Supporting mapping of local groundwater conditions in partnership with well contractors and others who collect groundwater information*

Develop a plan for aquifer protection that addresses geothermal construction and proper abandonment of wells.

Establish inspection requirements for residential wells, including testing wells for nitrates, bacteria and arsenic.

Develop a spill and communication strategy and organize an incident command approach to prevent, prepare for and respond to environmental disasters and chemical releases.

Properly Maintain On-Site Wastewater Systems

Michigan has about 1.3 million on-site wastewater systems (septic systems) that serve as permanent wastewater infrastructure for more than 30 percent of homes and businesses. At least 30,000 of these are commercial and community subsurface disposal systems treating sanitary wastewater with flows up to 10,000 gallons per day. Since more than half of new single-family homes are built with on-site wastewater systems, this reliance will continue to expand. However, no central system exists that tracks these on-site systems' precise locations, conditions or risks to sources of water. Adequately managed on-site wastewater treatment systems are a cost-effective and long-term option for meeting public health and water quality goals, but the key to their use is in proper siting, adequate management and maintenance.

Currently, local health departments in only 11 Michigan counties conduct inspections of on-site wastewater systems at the time of real estate transactions. These counties report that the number of systems in some manner of failure or improper operations averages about 10 percent but ranges as high as 23 percent. Assuming an average failure rate of 10 percent across the state, at least 130,000 systems discharging a total of 31 million gallons per day could be experiencing operational problems and adversely affecting local waterways and groundwater. Since local health departments issue only about 5,000 replacement permits annually for existing systems that have failed, there are likely a significant number of unidentified, failing systems statewide.

Michigan is the only state without a specific law related to individual or small-quantity on-site wastewater treatment systems. The systems are regulated to some degree, but the regulatory focus is largely on siting and construction of new systems and not on maintenance, system performance or condition. A combination of local codes and state

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criteria have contributed to a non-uniform patchwork of regulatory control over conventional septic tank and drain field siting, design and construction. A 2014 MDEQ stakeholder process concluded the state should develop science-based standards for site suitability, design, operation and maintenance, as well as requirements for oversight and inspection for all systems after construction. In addition, homeowner education about proper on-site system maintenance is needed and a state-facilitated loan mechanism to financially assist homeowners with on-site replacement should be explored. To date, this work has not been completed, and the Legislature has not passed such a statute.

Recommendations

Develop and implement a uniform statewide sanitary code that is flexible and provides standards for site suitability based on risk.

Establish a long-term sustainable funding source to support on-site wastewater programs at the state and local levels and to assist financially distressed owners of private on-site wastewater systems with repair and replacement costs.

Establish inspection requirements for residential on-site wastewater systems.

Develop marketing and education campaigns and outreach tools directed at homeowners regarding on-site wastewater management and maintenance and funding opportunities to assist with repair and replacement.

Clean Up Legacy Contamination

Michigan's historic industrial and commercial activities left many areas of legacy contamination. Some of the worst contamination problems in Michigan's waters still exist at superfund sites and in Areas of Concern (AOCs). In addition, the state suffers from more than 8,500 leaking underground storage tank sites and more than 9,700 other sites of environmental contamination. Common sources of contaminants include hazardous substance releases, contaminated sediments, atmospheric deposition, industrial discharges, sewage treatment plant discharges, combined sewer overflows, nonpoint source pollution and runoff from industrial sites. These sources of contamination threaten aquatic life, create an economic drag on communities, and prevent opportunities for use and enjoyment of Michigan's water.

Twelve of Michigan's original 14 AOCs remain on the list of formally designated areas of legacy contamination under the Great Lakes Water Quality Agreement. Today, 33 of the sites' 111 beneficial uses have been restored, with several more in the process of being formally assessed. Michigan recently celebrated the successful delisting of Deer Lake in Marquette County and White Lake in Muskegon County; all of their beneficial uses have been restored.

Public funds play a vital role in addressing contaminated sites where no responsible party exists or has the ability to fund cleanup activities. These funds are used to investigate the

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extent of contamination, evaluate and abate the risks associated with the hazardous substances present, and perform cleanup activities to protect the public and environment. They are also used to leverage private resources, stretching their impact. Funding programs like the GLRI (which must be funded annually and therefore is not a certainty), Great Lakes Legacy Act Program, Clean Michigan Initiative Bond, Brownfield redevelopment programs, and Leaking Underground Storage Tank cleanups contribute to Michigan's transformation. Their dollars turn blighted, unusable contaminated properties into opportunities for investment and revitalization in communities.

However, except for the GLRI, these funding sources are now nearly depleted. Continued advocacy for these important federal and state funding programs is needed to continue this transformational work. Critical cleanup efforts are still needed in Michigan to address other areas with significant contamination, including several areas within the Detroit River, the lower reach of the Rouge River, Velsicol Chemical on the Pine River in St. Louis and PCBs in the River Raisin, the Kalamazoo River, in the Ten Mile Drain on Lake St. Clair and in Torch Lake in Houghton County. While several of the locations mentioned above are currently under ongoing corrective action, work at many locations on the Detroit River and the lower section of the Rouge River are just beginning. Michigan cannot afford to give up the progress that it has made to this point, and there is more work to be done.

Recommendation

Secure a long-term funding source to accelerate the cleanup of legacy contaminated sites.

Prevent Environmental Impacts from Emerging Contaminants

New and emerging pollutants like antibiotics, endocrine disruptors found in fire retardants, rocket fuel, industrial wastes, existing and new pharmaceuticals, plastic microbeads, and pesticides and their metabolites are all now detected in the environment. The risk to humans, wildlife and the environment from any one of these, let alone the combination of them, is not well understood.

Effective removal varies based on the type of chemical and individual treatment system. Current wastewater treatment systems and drinking water plants are not designed to remove many of these new and emerging pollutants which can accumulate in waterways and cause harm.

Michigan uses surface water monitoring programs to identify and assess emerging pollutants. The state also relies on EPA's drinking water standard setting process, which includes periodic monitoring for new contaminants to determine how often the substance is identified, at what levels, and if a standard should be established to provide appropriate public health protection. Efforts should be taken to reduce environmental impacts from emerging contaminants through safe disposal, reuse or recycling, the use of technologies, product redesign or discontinued use.

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Recommendations

Pass comprehensive legislation phasing out the use and sale of microbeads in Michigan.

Establish research priorities for emerging pollutants of concern in partnership with Michigan's research universities to:

- *Better understand potential ecological and human health impacts*
- *Adapt monitoring protocols to detect concentrations, fate and transport*
- *Recommend standards for protection of human health and the environment*
- *Develop technologies to remove such pollutants from manufacturing processes*



CREATE

vibrant waterfronts



Chapter 3: Create Vibrant Waterfronts

Goal: Michigan communities use water as a strategic asset for community and economic development.

Outcome: Economic and community development plans and efforts fully leverage assets to create great places to live, work, and play.

Michigan's abundant water resources including its coasts, harbors, rivers, lakes and streams make many communities desirable places to live, work and play. Historically, Michigan's waterfronts supported industries such as shipbuilding, power production, lumber yards, tanneries and chemical production. Many communities developed commercial centers with their backs to the water. As industries abandoned the waterfront, many became eyesores and the public's connection to water as a community asset was lost.

But initiatives such as the federal Clean Water Act, corresponding state water regulations, strong local champions, and recent investments from the GLRI have turned polluted waters into thriving systems. As a result, communities began to rediscover their waterfronts and reimagine their communities focusing on their water resources. Water is once again playing a pivotal role in transforming communities' economies and is reflected in their values and desires.

Integrate Water Assets into All Planning Initiatives

Including water assets in community development reestablishes the connection between citizens and the outdoors, building a sense of place and improving overall quality of life. The way people relate to water in their community can drive ecological, economic and social outcomes. A stronger understanding of this relationship is needed to assist communities with economic and community development through proper land-use planning and form-based design.

By understanding this relationship, communities can more effectively integrate water as a strategic asset, maximize economic and social capital, strengthen the relationship people have to water, and avoid potential challenges with conflicting or unaligned policies or actions. Ultimately, creating greater opportunities to interact with local water resources can help foster a water conservation ethic in individuals and the community.

Research shows people are willing to pay more to locate to areas with access to clean water and good environmental quality.⁶ Residents drawn to these environmentally attractive places help communities create more wealth and more jobs. Studies by the Brookings Institution and Grand Valley State University show a 3-to-1 and 6.6-to-1 return,

respectively, on investments in restoring water quality and shorelines in the form of increased property values and local economic development.

Recommendation

Emphasize water resources as assets in state, regional and community planning efforts to provide appropriate sustainable protection and fully leverage community-based economic opportunities.

Foster Community Leadership to Reconnect Communities to Water

Fully leveraging water assets will require fostering community leadership and local champions. These leaders, both inside and outside of government, should fashion a comprehensive, community-informed vision, strategy and implementation plan for stitching water into the fabric of their communities. The strategy and implementation plan must balance both economic opportunities and environmental protection to ensure sustainability. Communities such as Alpena have embraced their maritime heritage with partnerships between the community and the National Oceanic and Atmospheric Administration's Thunder Bay Sanctuary. Grand Rapids is reimagining its relationship with the Grand River through its plans to reinstate its namesake rapids. The magnificent Detroit River transformation has been under way for nearly a decade under the leadership of the Detroit Riverfront Conservancy. Many other communities including Marquette, Flint, Kalamazoo, Battle Creek, Traverse City, Boyne City and Petoskey have also refocused the role that their waterfronts play in their community's vibrancy. Their experiences provide powerful case studies to share with other Michigan communities.

Recommendations

Host an annual mayor's summit focused on creating high quality communities that leverage strategic water assets.

Provide in-depth technical assistance to support communities with developing and implementing community visions and strategies for waterfront redevelopment, access and use.

Create Sustainable Commercial Ports and Harbors

Maritime trade use of the state's deep-water commercial ports is essential to Michigan, regional economies and many coastal communities. Investment in physical infrastructure is needed to maintain access to Great Lakes commercial ports while ensuring they are deep enough to accommodate commercial shipping vessels; this requires regular dredging. Michigan, however, has neither received nor dedicated adequate dredging funding. However, the maintenance of channels, ports and harbors is only partially the responsibility of the state and federal government and therefore needs to be incorporated into the business models of maritime companies.

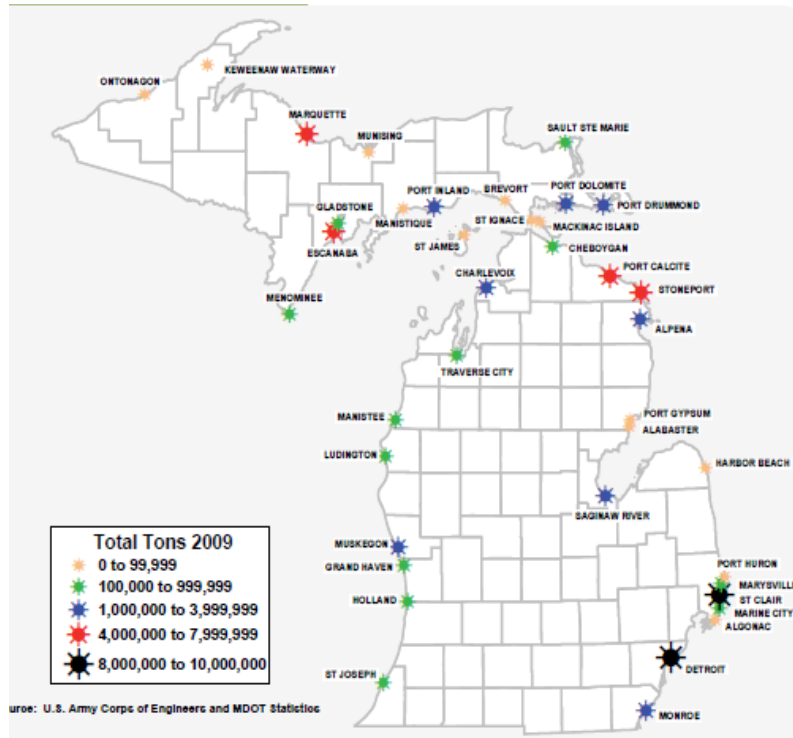


Figure 1: Cargo ports and tonnage
Courtesy of the Michigan Freight Plan

There are several on-going initiatives focused on commercial ports. Great Lakes and Canadian leaders have begun a region-wide assessment of maritime infrastructure, long-term funding, and management through their Great Lakes Maritime Initiative.⁷ Also the Great Lakes International Trade and Transport Hub (GLITTH) initiative, a joint effort managed through Michigan State University and the University of Halifax, attempts to leverage Detroit's and Port Huron's infrastructure assets to make southeast Michigan the largest international trade gateway in the country.

Major ports like Fisher Port in Saginaw, Muskegon Lake, and the Ports of Detroit and Monroe are all using public and private investment to reestablish or upgrade port infrastructure. But significant opportunities to develop Michigan's ports as multimodal transportation hubs remain. In addition, few of the state's commercial ports currently receive or ship agricultural products; this potential growth area could significantly benefit both sectors.

Recommendation

Prioritize investments around strategic economic assets of commercial harbors and long-term sustainable infrastructure.



SUPPORT

water-based recreation



Chapter 4: Support Water-Based Recreation

Goal: Michigan's water resources support quality natural resources, recreation and cultural opportunities.

Outcome: Waters of the state are world renowned for water-based recreational pursuits such as hunting, fishing, boating and swimming.

Michigan's four Great Lakes, 11,000 inland lakes, 76,000 miles of rivers and streams, and 3,200 miles of freshwater coastline provide abundant water-based recreation opportunities, making Michigan a great place to live and play while also supporting a thriving tourism industry. However, challenges and opportunities exist in sustaining and expanding the state's water-based recreational opportunities.

Improve Beach Health

Beaches are among the fondest memories of Michiganders' summer vacations. But pathogens such as *E. coli* threaten this treasured asset. The Great Lakes and inland public beaches are monitored for pathogens on a voluntary basis by local health departments, supported by MDEQ which awards grants for this purpose. In 2013, 98 beaches reported 162 incidents of *E. coli* exceeding accepted water quality standards, causing advisories or closures. While the durations were typically short, usually one or two days, any closure impacts recreation and tarnishes the state's image. Causes of beach contamination include releases from wastewater treatment plants, sewer overflows, leaking septic systems, runoff from agricultural operations, and excessive wildlife on beaches. These causes are addressed in other sections of the Water Strategy; however, additional real-time beach monitoring data is also needed to provide timely advisories that protect public health.

Recommendation

Expand the use of real-time monitoring and source tracking techniques at high-risk beaches by local health departments, counties, communities and universities and address sources of beach contamination.

Address Fish Consumption Advisories

Michigan continues to need guidelines on safe fish consumption amounts because of ongoing and historical deposition of persistent, bio-accumulative toxic (PBTs) pollutants like mercury, PCBs and banned pesticides such as DDT. Addressing sources of ongoing deposition and sites of legacy of contamination is critical to restore human use and enjoyment of fishery resources.

In some cases, global sources are contributing to atmospheric deposition of mercury and other PBTs and will require a state, regional and national approach to reduce emissions.

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Michigan's participation in national and regional efforts to eliminate anthropogenic mercury use and releases is critical to having an impact on this global problem. The MDEQ's 2008 Mercury Strategy report estimated most of the mercury released into the environment is released into the air, with a smaller amount being released directly to water and land. A 2002 inventory estimated about 7,000 pounds of mercury were emitted into the air in Michigan that year. About 37 percent was from coal combustion and about 30 percent was from the purposeful use of mercury. This estimate has been used to establish a baseline for measuring progress toward reducing emissions. Between 2002 and 2011, ongoing pollution prevention activities, permitting and regulations resulted in mercury air emission reductions of 1,000 to 2,000 pounds of mercury. Coal-fired power plant retirements and use of additional coal combustion control equipment may eventually reduce mercury emissions in Michigan by 80 to 90 percent.

Although atmospheric deposition of Hg, PCBs and other PBTs cause most of the fish consumption advisories in Michigan, the most restrict advisories are caused by site specific legacy issues. Examples include the "do not eat" advisory covering all species of fish downstream of the former Velsicol site on the Pine River and covering all species of fish on the Kalamazoo River between Morrow Dam and Lake Allegan because of past practices at paper mills. Some restriction advisories have been successfully removed in Michigan's AOCs due to restoration efforts over the last several decades. The GLRI has enabled rapid progress toward restoring human uses of fishery resources. Sustained support for the GLRI is needed to continue progress.

Recommendation

Continue national and regional coordination of mercury reduction activities, such as implementation of the Great Lakes Mercury in Products Phase-Down Strategy and the Great Lakes Mercury Emission Reduction Strategy.

Ensure Sustainable Recreational Harbors

Michigan has more than 80 recreational harbors that contribute significantly to the quality of life and economic vitality of host communities. In addition, the harbors also help support Michigan's \$4 billion boating industry.⁸ Unfortunately many harbors are in poor or failing condition and limited financial resources hamper sustainability.

The Department of Natural Resources completed an inventory and condition assessment of recreational harbor infrastructure in 2014. Additional research, planning and prioritization are needed to identify critical sources of sediment that diminish the value of the harbor and increase maintenance costs, prioritize long-term capital investment needs, and create strategies to market harbors.

A multi-agency and university partnership is also conducting assessments to evaluate the complexity of the issues facing harbors while developing community guidance to ensure sustainability. Too often communities have not realized the full economic and social value

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of their harbors; rarely are they integrated into community and economic development plans. This integration is necessary for prioritizing and leveraging capital investments. Variable lake levels, infrastructure condition and depreciation, access, boating trends and future use of the harbor all need to be considered to ensure harbor and marina sustainability.

Recommendations

Prioritize infrastructure needs for repair and upgrade of public recreational harbors and their landside access.

Establish a harbor town program and improve marketing of harbors. The program should work with MDEQ to identify and address sources of upstream sediment, including sediment reduction and relocation strategies.

Increase Access to Lakes, Rivers and the Great Lakes

Since water plays such a pivotal role in many Michiganders' lives, access has always been a priority. In 1939, the Legislature first earmarked funds to purchase water frontage to improve access for fishing and boating. Since then, more than 1,200 public launching sites have been developed for boaters. The Natural Resource Trust Fund remains an important part of providing recreational opportunities, including access to Michigan's waters. But with more than 11,000 lakes and thousands of miles of rivers, streams and Great Lakes coastline, significant gaps in access remain. The 2013 Department of Natural Resources Managed Public Lands Strategy and the Great Lakes Water Trail Plan both recognized this need. Of course, protection of ecologically sensitive areas needs to remain foremost when addressing access gaps.

Recommendation

Work with local partners to provide public access every five miles on the Great Lakes, on all priority lakes more than 100 acres in size and every five miles on navigable water, as environmentally appropriate.

Designate Water Trails

Michigan has endless opportunities for establishing a spectacular water trail system. Much of the framework for such a system already exists, and some water trails have recently been developed on several rivers using existing access sites, harbors of refuge and waterside campsites. Statewide criteria for designating a trail is needed, including level of difficulty, distance between access sites, and trail amenities such as nearby campgrounds, restaurants and restrooms.

Recommendation

Work with stakeholders to develop and implement a designated water trail system for inland waterways and along the coast.



PROMOTE

water-based economies

Chapter 5: Promote Water-Based Economies

Goal: Michigan has a strategic focus on water technology and innovation to grow sustainable water-based economies.

Outcome: Policies and innovative technologies are developed and adopted to grow and promote sustainable water-based economies.

The Great Lakes and Michigan's water in general, have played a defining role in the state's economy starting with fur trading and continuing with the lumber boom, agriculture, manufacturing and tourism. Michigan should leverage this past experience by marketing its strategic advantages as the Great Lakes state, growing leadership and harnessing talent in research and development, accelerating innovation in water technology, and optimizing water efficiency. Michigan and other places across the globe face complex challenges in addressing water quality and quantity concerns. The state is well-positioned to be a powerhouse for solving these complex problems and grow its economic opportunities around water in a manner that ensures good stewardship of the resource. Collaboration among industry, regulators, economic developers and academia directing water research and development is the right place to start.

Market Michigan's Strategic Advantages

Part of Michigan's appeal is its availability of freshwater and ability to manage water-related risks. Currently, Michigan hosts about 350 companies that provide technology, goods, and services related to the supply, treatment, distribution, storage, transport, recycling, rehabilitation and conservation of water. As a recent University Research Corridor analysis highlighted, more than one out of five jobs in the state are strongly linked to water, a number that does not include outdoor recreation and tourism, which alone contribute \$10 billion to the economy annually.⁹

The recognition of water as central to healthy systems, people and economies is growing. Electric utilities, mining, steel manufacturing, and the food and agricultural sector potentially face high costs as a result of water scarcity across the nation, due to the high capital costs for alternative supplies, reliance on a small number of assets and their relatively large volume of water use. Water-intensive companies in water-stressed areas are at the highest risk of experiencing production disruptions, stranded assets, increased capital costs and community conflicts over shared resources.

Water is a key factor in the economic health of many corporations and therefore a significant and knowable element in overall corporate stock price and volatility. In a 2015 survey, the World Economic Forum ranked water crises first as a critical risk to the global

economy.¹⁰ According to a Pacific Vox survey of 50 Fortune 500 companies from a broad cross-section of industries nationwide, concern about water scarcity has grown dramatically during the past five years. By 2018, 86 percent of the companies expect to consider water availability in their site selection, up from 37 percent in 2008.¹¹

Water is now seen as a factor in the movement of trillions of dollars of capital and investment. Researchers, financial managers, investors and corporations are beginning to fully understand how water contributes to or mitigates risks throughout the business cycle. A key challenge that investors face is how to quantify and value financial risks from regulatory, physical and reputational impacts from water. The University of Michigan is conducting innovative research about water risk and corporate behavior, but further research is needed about the value the state's water resources can add to managing water-related risk, stock price volatility and overall financial performance.

Recommendation

Market the state's competitive advantage as a highly attractive place for business creation and investment because of our abundant natural water assets, water research capabilities, highly skilled talent, economic development expertise, and powerful tourism and business-marketing brand.

Optimize Efficient Use of Water in Business, Utilities and Municipalities

If Michigan's abundant clean water supply is efficiently managed, the state's economic capacity can grow while ensuring water stewardship. In a state with generally abundant water resources, it is difficult to appreciate that water is not disposable and that every drop is valuable. There are some areas of the state experiencing localized water scarcity, where this appreciation needs to spread across the state to ensure the sustainability of this precious resource. All Michiganders have an obligation to be good and thoughtful stewards of this global treasure by using water more thoughtfully and efficiently.

Under the Great Lakes Compact Agreement, each state is required to establish water conservation measures on each water use sector; however, limited data is available on current water use for each sector beyond gross numbers and anecdotal information. Without goals or objectives, we cannot evaluate progress in reducing water use impacts and determine if improvements are needed.

Nevertheless, some progress toward conservation is underway. Businesses are beginning to focus efforts around water sustainability to improve their bottom line and comply with environmental standards. Others are recognizing the importance of water globally and are beginning to work more holistically outside corporate walls. For example, Ford Motor Company, Consumers Energy, General Mills, Amway and Dow are all deeply engaged in water management as part of their corporate sustainability and operational programs, many of which have set aggressive water efficiency targets. Consumers Energy set a water

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reduction target of 20 percent between 2012 and 2020. Ford Motor Company set a goal of reducing its water footprint by cutting the amount of water used per vehicle by 30 percent globally between 2009 and 2015.

The Great Lakes and St. Lawrence Cities Initiative (GLSLCI) also urged cities to participate in the GLSLCI Water Conservation Framework to help meet its commitment of reducing water use within city limits by 15 percent in total water usage by 2015 using 2009 water consumption levels as a baseline.

Conservation makes not just social sense, but business sense. Water is heavy, requiring a significant amount of energy to move through the system. Measureable water loss can be attributed to leaking and poorly maintained municipal infrastructure. In addition, cleaning and purifying water for drinking water, manufacturing and discharge is very costly. Nationally, between 4 percent and 13 percent of all energy is used to pump and treat water, for waste management, or for industrial and commercial processes.

For businesses and industries that require water use as a core part of their operations, energy (and cost) savings can happen in two ways: increasing the efficiency of pumping and treating water, or by reducing the total use of water per capita per industrial or municipal process. Capital asset management planning and infrastructure upgrades should reflect these goals.

Wastewater reuse through energy generation also provides economic opportunities. Innovative solutions to wastewater management can minimize water and energy footprints. Firms like Moore and Bruggink have reengineered Greenville's wastewater treatment facility to produce its own energy, reducing costs and energy consumption by more than 30 percent.¹²

In addition to using less water through efficiency measures, water reuse should be explored in situations where potable water quality is not required and risk for cross-contamination is low. This must be done with critical attention to public health and infrastructure. Michigan should develop standards, protocols and strategies to protect public health and preserve surface water and groundwater resources while facilitating rain and grey water reuse in appropriate situations.

Recommendations

Establish voluntary water efficiency targets for all major water sectors to reduce water use impacts and costs.

Promote innovative technologies that reduce cost and water loss or convert waste products to usable materials.

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Develop a water conservation and reuse strategy for the state that incorporates the use of green infrastructure, grey water systems and energy production and includes recognition programs.

Fund a pilot project, through a competitive bid process, for the initiation and evaluation of a new model for wastewater management. This pilot program will assess the opportunities and barriers to creating a "Water Resources Utility of the Future" focused on:

- *Reclaiming and reusing water*
- *Extracting and finding commercial uses for nutrients and other constituents*
- *Capturing waste heat and latent energy in biosolids and liquid streams*
- *Generating renewable energy using its land and other assets*
- *Using green infrastructure to manage stormwater and improve urban quality of life*

Optimize Efficient Use of Water for Agriculture

Agriculture is another example of a major water user in Michigan that has made significant advancements to improve efficiency. Water, energy and food are inextricably linked. Growing populations, improving technologies, high crop prices and specialty crops like seed corn have led to expansion of irrigation and agriculture production into regions of the state where it was once unfeasible. Biotechnology advances, especially shorter-season crop varieties, and climatological and meteorological changes with accompanying longer growing seasons make farming in the northern part of the state a more viable opportunity.

As agriculture continues to grow in Michigan, there will be greater pressure on aquifers and more potential for use conflicts. More intensive use of land will require greater management of water. While total agricultural water use is increasing, the efficiency of the transformation of water into crops is also increasing. There are opportunities for agriculture to use more sophisticated irrigation delivery and water management systems to reduce water use per unit output. Continued efforts to increase efficiency can reduce conflicts in localized areas that have water shortages, reduce related energy costs, and reduce water use impacts. There are many synergies and trade-offs between water and energy use and food production. The goal is not necessarily to reduce water use, but to reduce the impacts of agricultural water use on ecological systems and to use it more judiciously.

Aquaculture is another area that could thrive based on Michigan's plentiful water supply and high water quality. In a world demanding ever-increasing amounts of high-quality fish and protein, growing the state's aquaculture industry will require significant innovation in water technology. In particular, industry and the state should continue to support closed-loop or recirculating systems. Lowering energy costs of production, improving water filtration and strengthening supply chains for commercial aquaculture systems will enable the industry to grow substantially in an ecologically responsible fashion.

Efficient use of water also affects the processing and manufacturing supply chain. Companies like Kellogg, MillerCoors and General Mills are focusing efforts around water sustainability by working with the agricultural community to implement best practices, such as efficient delivery of water to crops, efficient use of water, and impact accountability. In areas with water scarcity issues like Texas, Colorado and other western states, technological advancements are reducing pressure on aquifers with inadequate recharge. Establishing targets for water efficiency in areas with localized water stress may reduce the potential for conflict.

Recommendation

Establish voluntary water efficiency targets for agriculture in areas of existing or potential water stress.

Accelerate Innovation in Technologies to Solve Water Challenges

Michigan can advance the technology, science, research and education required to improve water management. These water technologies can be an economic driver for the state. To capture its share of the global water technology sector, predicted to reach \$1 trillion annually by 2020, Michigan must nurture an environment that fosters water entrepreneurs, supports a high-performing water technology sector, and leverages the state's innovation, research, development and extensive manufacturing capabilities.

Michigan faces a number of complex challenges regarding water quality and quantity but the state also has a history of developing innovative water technologies to help meet those challenges while exporting those technologies to global markets. Different water sectors – municipal, agriculture, manufacturing and industry – all have specific needs requiring technological solutions such as maximizing water efficiency, minimizing water loss, meeting more rigorous discharge standards, and dealing with new forms of contamination from emerging chemicals and pharmaceutical products. A recent report on Michigan's Blue Economy by the Michigan Economic Center and Grand Valley State University Annis Water Resources Institute highlights examples of successful efforts to develop and deploy cutting-edge water technologies to address some of these needs and challenges.¹³

Michigan has the ideas and research; academia, businesses, and end users need to align goals and desired outcomes for technologies to actually reach the market. Focusing on innovation in water technologies does not represent a philosophical change to the state's approach to economic development but rather recognizes the importance of aligning interests, making clear statements about priorities, and connecting the pieces together to drive entrepreneurial innovation. By building robust public-private partnerships, Michigan can link innovation, research and development, capital investment, entrepreneurialism, and end users to achieve desired environmental, economic and social outcomes. When an accelerator of public and private funding is combined, ideas can move more quickly from design to deployment and markets.

Recommendation

Create a strategic focus on water innovation to attract and accelerate new technologies to market through a business led council comprised of private investors, entrepreneurs, corporations, public agencies and universities to better manage water challenges in Michigan and worldwide.



INVEST

in water infrastructure

Chapter 6: Invest in Water Infrastructure

Goal: Michigan invests in infrastructure and supports funding to maintain clean water and healthy aquatic ecosystems.

Outcome: People support investment of both public and private funding in Michigan's water resources.

The state's infrastructure – roads, commercial ports, drinking water systems, sewer systems, energy plants, transmission systems and recreational facilities – form the backbone of the economy. All water withdrawn from the Great Lakes, groundwater, rivers, and lakes for any purpose passes through some form of water infrastructure; it is a complex system. A functioning water infrastructure system keeps the state running.

Improve Understanding of the True Cost of Water

Most people think of their monthly water bill as the cost they pay for water. But in reality, water, as a natural resource, is actually free for any purpose and for any amount used by any entity, public or private, as long as its use does not degrade the resource. Water is free to those who want water to drink, to businesses that use it in industrial processes, to those that bottle it for consumption and to homeowners who water their lawn. The economic value of water is nearly infinite, but for Michiganders it is a free, shared resource to use for all kinds of human purposes. While water as a resource may be free, there are costs associated with managing Michigan's water resources to ensure that water is of high quality and available for human uses.

Through their water bills, Michiganders instead pay for the infrastructure to deliver safe drinking water and carry away and treat waste, and for the operating costs, like energy, to treat and condition water and maintain infrastructure. Those outside the area of a municipal water supply system pay for well construction, treatment if necessary, the pump and the energy used to supply water to the tap. In addition, the cost of infrastructure to supply water is contained in the final price of all commodities and services.

Water's cost is determined by volume-based pricing that allows the collection of revenues to pay for infrastructure and operations used to deliver water. Under this scenario, there is often a lower per unit, usually gallons, fee on water for higher volume users and amounts. Water rates are commonly skewed in such a way that users pay less as volumes rise, because the price is pegged to infrastructure costs and not to the value of water itself. In some instances, this can act as a complicating factor when trying to achieve water use reduction or conservation, as conservation equates to lower revenues for municipalities.

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A customer's use of less water does not necessarily or directly equate to lower operational costs of infrastructure. There is still a substantial cost to have safe drinking water delivered at adequate quantities and pressures whenever the tap is opened and to have fire protection available at the curb within the reach of a standard fire hose in event of an emergency.

Michigan has a long experience and legal history of not putting a commodity price on water, thus keeping water a free resource, and an important element of the state's economic and social well-being and stability. During public outreach for the Water Strategy, many residents suggested either putting a fee on water for all or some groups of water users – in its simplest form, a per gallon charge for water as it comes from the environment. Some suggested that only some types of water users, like agriculture, water bottlers or industrial users should pay a per gallon fee for withdrawing water. Others suggested all users should pay a surcharge or a per gallon fee for the use of water, regardless of user or purpose. Given that Michigan's citizens and businesses withdraw more than 4.2 trillion gallons per year, equivalent to the amount of precipitation that falls on the U.S. per day, even a tiny surcharge or access charge would add up quickly. The economic logic may make sense in the abstract, but it does not currently fit the culture and history of water and water use in the state.

Conversely, some argued that adding a price to water, even as an access charge versus a price on water per se, would commodify the resource, when it has historically been a public good or a public trust resource. Maintaining the ability to manage and ensure the sustainability of the water resources of Michigan and the Great Lakes is of utmost value to the state and the region, and even though a revenue stream could be created from a volume or access charge on water, the values potentially compromised under this scenario are too great to lose. However, there is still a compelling and growing need for investments in water and water infrastructure and for administrative and programmatic support in order for the state to meet its long-term vision for healthy, functional systems and prosperity.

To address the gap between actual investment need and public perception of that need, Michigan should launch a public education campaign to improve residents' understanding of the economic, environmental and social benefits of clean water, linking the investments necessary to achieve the benefits. If the public wants clean beaches and good water quality – and they say they do – public support of water infrastructure investments is critical. While we do not seek to facilitate a volumetric surcharge on water access, if that is something the public would ultimately support, then it would add to the options for funding long-term infrastructure and desired outcomes.

Water rates have historically been low and water both plentiful and affordable in most Michigan communities. Detroit's recent water shutoffs, the loss of urban population in other communities, and an overall increase in domestic water conservation has put a

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sharper focus on water rates, affordability, and the ability to continue to fund aging infrastructure costs. There is currently no statewide assessment of shut-off practices or policies that relate to affordability and water access for human use.

Recommendations

Implement a communication strategy focused on messages that link the relationship between investments in water infrastructure and clean water as well as the benefits infrastructure provides for drinking water, recreation, cultural and economic opportunity.

Utilize pricing and funding strategies to support infrastructure improvements while allowing for water conservation.

Evaluate current community practices regarding providing water to financially distressed customers to ensure all citizens have affordable access to water for drinking and sanitation.

Invest in Water Infrastructure

One of the biggest challenges facing communities is aging, deteriorating infrastructure systems with more operational needs than financial resources to meet them. Poor infrastructure degrades the value of water, results in costly efforts to mitigate impacts, and creates or increases drag on the economy.

In a perfect world, users of the system would pay for the cost of service. Rates would consider operation and maintenance costs as well as long-term capital investment needs. Unfortunately, rates in Michigan are typically set by elected officials who have political difficulty charging rates necessary to maintain infrastructures.

Asset management planning, performed properly, would support municipalities' efforts to optimize future costs and collect revenues sufficient to operate and maintain the system. Since 2013, some large municipal wastewater treatment plants have been required to develop an asset management plan as part of their nonpoint source discharge elimination standard (NPDES) permit; however, this requirement doesn't apply to all water utilities. Outcome-based asset management planning that includes more efficient use of resources can result in cost efficiencies that can be used to address capital costs while keeping rates affordable.

Communities can realize cost efficiencies to manage water infrastructure systems and to meet the needs of the future by increasing efficiencies in the delivery and treatment of water through implementation of energy efficiency measures, the use of technologies and a combination of grey and green infrastructure. A more integrated systems approach can improve water management, reduce energy costs and result in savings for communities as opposed to investing in traditional methods which typically have higher capital investment costs.

If communities continue to use traditional methods to manage infrastructure, conservative estimates range in the billions to improve stormwater, drinking water and wastewater management systems over the next 20 years. Although a large majority of these costs are not the responsibility of federal or state government, the state needs to implement a long-term strategy to sustain state water programs, including funding to maintain critical regulatory oversight programs, water quality monitoring and provide assistance to communities to local water infrastructure. In addition, the state should explore a variety of options to close the widening gap between existing funding sources and future revenues needs, including incentivizing asset management planning, state bonding and borrowing options, dedicated capital and trust funds, public-private partnerships, insurance and leveraging, private equity, and service area consolidation. Without adequate funding, Michigan's economy, aquatic ecosystems and quality of life will be diminished.

Recommendations

Incentivize and require outcome-based asset management planning for all public water utilities that includes more efficient use of resources.

Establish sustainable funding mechanisms to achieve Water Strategy goals including water infrastructure management.

Develop an Enterprise Budget for Water

The state needs to complete an enterprise budget to more fully understand the complex relationships between water, infrastructure needs and funding across all entities, including state agencies, federal agencies, local municipalities, drain commissioners and inter-county drain boards. An enterprise budget is a theoretical budget – not a responsibility budget – that portrays revenue and expenditures regardless of agency or governmental unit. The four principle revenue sources related to water in the state – federal, state and local revenues and fees, and private revenues – should be included in the enterprise budget as shown in Figure 2. This budget will also assist in understanding how to maximize the sustainability of the funds used to support water infrastructure and state programs.

Michigan – Statewide Enterprise Budget for Stormwater, Drinking Water and Wastewater Management

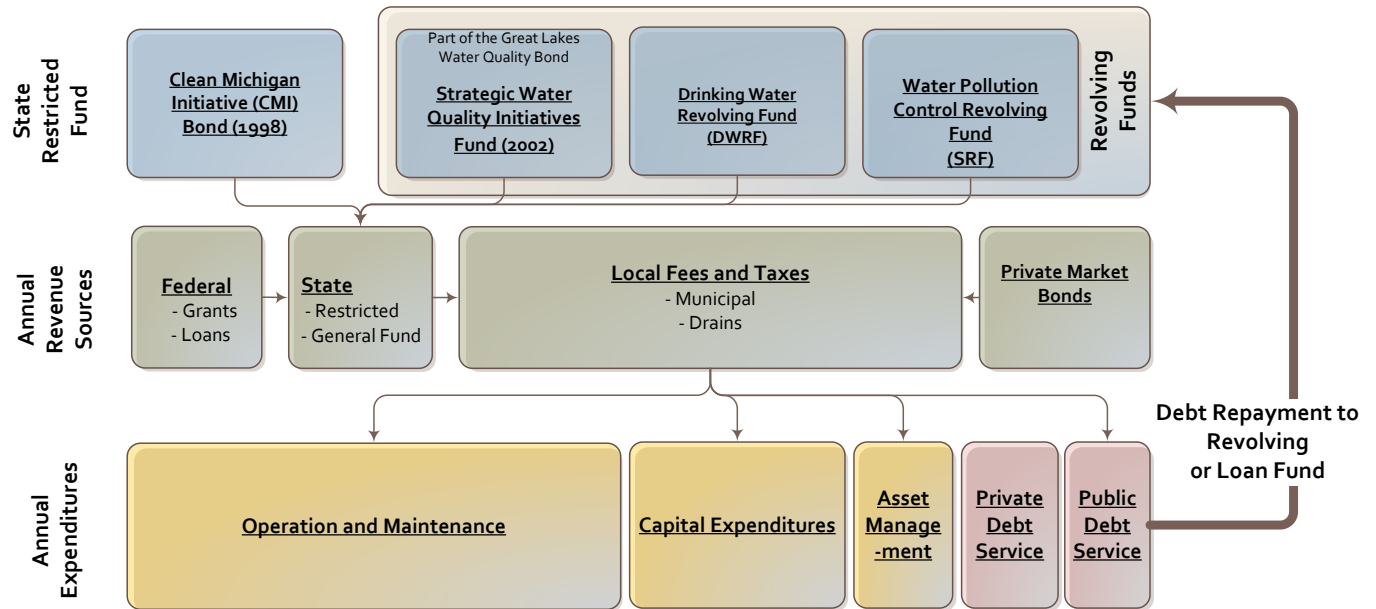


Figure 2: Conceptual statewide enterprise budget for stormwater, drinking water and wastewater.

Recommendation

Develop an “enterprise budget” to better understand the complex relationships between managing water, infrastructure needs and funding.



MONITOR

water quality

Chapter 7: Monitor Water Quality

Goal: Michigan has integrated outcome-based monitoring systems that support critical water-based decisions.

Outcome: Monitoring systems are in place at a scale and frequency to ensure water quality and quantity are maintained to support diverse uses and values.

Michigan's water presents undeniable economic growth opportunities, but appropriate monitoring to integrate economic, environmental, social and cultural data is critical to achieving this goal.

Michigan's current monitoring programs do not incorporate all components of the ecosystem and face significant funding challenges. Lack of systems-based monitoring approaches and inadequate data collection impede economic growth, detection of environmental and human health threats, and evaluation of program effectiveness. We must improve monitoring efforts and critically assess progress achieved across economic, ecological, social and cultural outcomes. The results should be used to determine how to best direct and connect management actions and future investments.

Build Integrated, Outcome-Based Monitoring Systems

Michigan needs to develop an integrated, water-based monitoring system that builds on collected data to create logical connections in an overall information system. This integrated system should include quality and quantity monitoring, condition assessment, modeling, and forecasting tools for the entire water cycle. It should be made publicly available and used by government and other organizations to better communicate the benefits of healthy water systems to residents and communities.

Monitoring practices have traditionally measured some, but not all, of the components of the ecosystem. It has narrowly focused on the ecological condition of fish, wildlife and water, compliance performance, and human health while placing less emphasis on outcomes related to system and economic performance, social and cultural impacts, and environmental factors.

In 2014, the University Research Corridor completed the first economic analysis that estimated the economic, social and cultural performance of water.¹⁴ This approach is consistent with efforts undertaken by the Council of Great Lakes Governors and Premiers to develop systems-wide accounting and monitoring. A recent effort, called "Blue

Accounting,” seeks to integrate monitoring systems across ecological, use and social values at the Great Lakes scale. An integration of these components is shown in Figure 3.

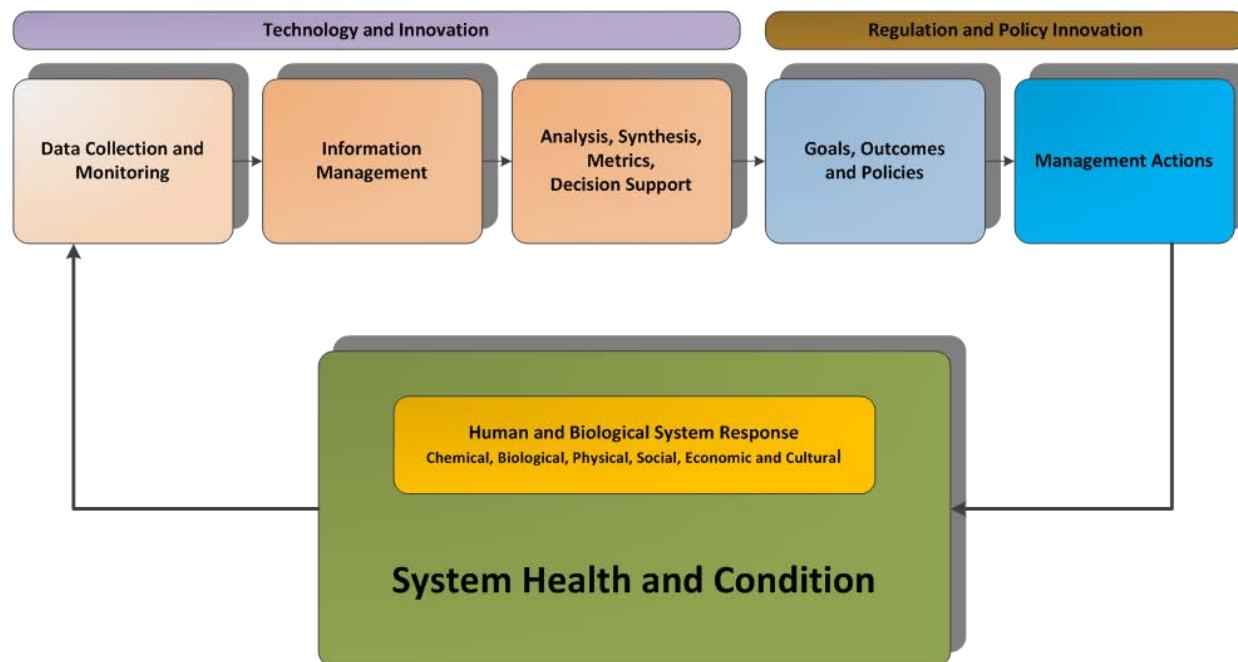


Figure 3. A schematic representation of an integrated system of monitoring and accounting.

Recommendation

Implement a pilot decision-support framework that includes monitoring, data and information, and analytical tools. This framework will assess ecological, economic, social and cultural values and outcomes at local and regional watershed scales.

Support Funding for Monitoring

Comprehensive monitoring of surface and groundwater is expensive and therefore typically funded piecemeal; however, if water quality is not maintained, public health, ecosystems, businesses and recreation suffer.

Michigan’s Surface Water Monitoring Strategy focuses on achieving four goals:

- Determine whether water quality standards are being met
- Measure water quality trends
- Evaluate the effectiveness of water programs
- Identify emerging water quality issues

The 1998 Clean Michigan Initiative (CMI), a \$675 million environmental and recreation bond, dedicated about \$3 million per year to surface water quality monitoring. This bond is nearly depleted, and an alternative, long-term, stable source of funding for surface water monitoring needs to be identified.

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Some critical components of the Surface Water Monitoring Strategy are currently not adequately funded by CMI or any other funding source including stream flow monitoring and microbial health.¹⁵ Data that link microbial health to site-specific land-use, wastewater management, manure management and hydrology are limited. For example, this information is critical for future management actions and investments such as how and when specific sources of *E. coli* trigger beach closures. In addition, better data management systems that include geospatial information are needed to enable integration of existing and new monitoring data at spatial scales.

Michigan lacks a coordinated and comprehensive strategy for monitoring groundwater quality and quantity to improve understanding of this valuable resource, reduce threats of contamination, and guide better investments and decisions. Monitoring and mapping the stores and flows of groundwater and use patterns to account for its use, removal from the environment, effects on aquatic systems, and its return to the environment is critical to understanding and ensuring sustainable use of groundwater resources.

The state needs to secure a long-term funding strategy for groundwater monitoring and management. Current efforts are funded and managed by an array of sources, resulting in fragmented monitoring approaches.

Recommendations

Develop a coordinated, comprehensive monitoring strategy for groundwater quantity and quality, including a data management system.

Develop a long-term, sustainable funding source for groundwater and surface water quality and quantity monitoring that is continually improved with new technologies.



BUILD

governance tools

Chapter 8: Build Governance Tools

Goal: Michigan has the governance tools to address water challenges and provide clean water and healthy aquatic ecosystems.

Outcome: Policies, organizational and institutional structures are in place to achieve the goals and outcomes of the strategy.

Water resource management in Michigan is facing increasingly complex problems that will require new and different knowledge and approaches that broaden participation in governance. Governance, as defined by Kooiman¹⁶, is “arrangements in which public and private actors work to solve societal problems, create societal opportunities, and design the societal institutions within which governing actions take place.”

Work led by Michigan State University in the late 2000s, Critical Conversations about Environmental and Natural Resource Governance¹⁷, concluded “A new model [of governance] may well require that individuals and groups beyond traditional state government structures play important roles in implementing management initiatives and monitoring outcomes.”

This work was informed through an extensive set of conversations facilitated by the MDEQ’s Environmental Advisory Council, which concluded that “Michigan will benefit from a new model of environmental and natural resource governance that benefits from collaborative efforts to develop agreed-upon outcomes, focuses on prioritization and relative public health/environmental risk, encourages innovation, provides for continuous improvement, promotes performance above minimal compliance, and engages voluntary environmental stewardship.”

This effort also concluded that what worked in the past to manage the environment might not be sufficient to address new and changing challenges with diminishing resources. This does not mean that old tools need to be discarded. Instead, the existing regulatory framework needs to be augmented alongside new tools and new approaches.

Facilitate Community-Based Dialogue and Water-Related Vision Development

The Strategy focuses on actions at the community level to develop vision, create collaborations and find local champions that can galvanize local unity. The ultimate goal is to marshal the financial and human resources to drive the vision ahead. Many regions and communities are already engaged in this important planning and implementation work, while others are just beginning. Through the community conversations conducted as part

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of this strategy development and generously supported by the C.S. Mott Foundation (Appendix 2e), communities are seeking help in two ways:

- Forming and designing their community vision relative to water and their water assets
- Identifying tools and resources to fulfill that vision

Community, regional and statewide foundations are central to supporting this effort. These organizations need to work together to support community planning around water. The state, through its grant-making capacity, collaborative programs, networks and outreach efforts, needs to support and augment these local efforts.

Recommendations

Enhance the understanding, knowledge and skill set of communities to facilitate and support community-based dialogue and water-related vision development.

Create a statewide Water Fellows Program and Network to build community leadership capacity and to inform critical local leaders about how to leverage water resource assets to build community and economic vitality.

Align Resources, Tools and Regulatory Framework to Achieve Outcomes

Water resources are managed at various scales and by many levels of government. State-level regulations and policies establish performance expectations for managing important water and water-related resources. Great Lakes region-level regulations manage water diversions and flows and help prevent evasive species introductions such as Asian Carp through the Chicago Area Waterways System. Other regulations are national in scope.

Management of water resources at the local level is also important. Much of the state's rainfall and runoff is managed at the county and inter-county scale through county drain commissions and inter-county drainage districts. A thoughtful review of Michigan's existing tools, resources and regulatory framework for managing water at the local level is necessary to address emerging water problems that don't respond to traditional approaches methods. New approaches such as collaborative watershed governance may be needed to more effectively manage water across the landscape to achieve desired water quality and quantity outcomes. Partnerships, collaborative decision making and joint project implementation at the watershed scale that involve government, business, the building industry, agriculture, and environmental and other stakeholder organizations are a few examples of this approach.

Recommendation

Evaluate and implement necessary changes to laws including state and local land-use statutes as well as the drain code to create a more integrated, watershed based system for managing water at the landscape level and achieving water quantity and quality outcomes.

Retain Regulatory Tools

The state's water resources, as well as communities and businesses dependent on these resources, benefit from Michigan's authority to implement the provisions of the Clean Water Act, including Section 404 pertaining to wetlands and Section 402 pertaining to pollution control. Through state laws, Michigan maintains consistency with federal laws related to management of its wetland, lake and stream resources, and creates streamlined permitting systems to address Michigan-specific issues. Recent changes to several water resource laws have caused some to question whether Michigan's water resources would be "better off" if authority to regulate these resources was returned to the federal government. Others believe the cost for retaining federal authority is too great, but don't fully understand the cost to business for less permitting certainty and long processing times. Given that water and water resources are of critical and strategic importance to the state, it is in the state's long-term interest to exercise authority and autonomy over their thoughtful management.

Recommendation

Retain full authority under the Clean Water Act to continue to manage Michigan's own water resources.

Ensure the Water Strategy is Durable Over Time

The Water Strategy is not only about what government does or funds, but about what Michiganders do collectively to support healthy systems, human use and enjoyment, and a growing water economy. In order to ensure the Water Strategy is durable over time and across administrations, the elements of the Strategy need to be fully integrated into decision processes, governance structures, and the culture of state and local governments, other organizations, and individuals. Where Michigan places the nexus of responsibility for decision-making, whether on individuals, local governments or the state, matters. What goals residents and leaders focus on matters. How the state governs water quality, quantity and use matters.

Ensuring sustainability of the Water Strategy and its long-term implementation will depend on how the various recommendations get adopted by various actors or organizations and get funded, supported and realized. If the critical elements of this Strategy are not adopted and deeply engrained into ongoing decision-making processes, then little will come of them over time. Adaptive management approaches are needed to evaluate progress and make necessary course corrections to achieve desired outcomes.

Recommendation

Create an Interdepartmental Water Team to unite agencies to ensure a cohesive common strategy around implementation of the Water Strategy. The team will establish a process for stakeholder collaboration, criteria for setting implementation priorities, identifying cross-agency joint projects, and an approach to assess and evaluate progress achieved against the metrics and outcomes.



INSPIRE

stewardship for clean water

Chapter 9: Inspire Stewardship for Clean Water

Goal: Michigan citizens are stewards of clean water and healthy aquatic ecosystems.

Outcome: Individuals and communities understand their responsibility for and make responsible decisions regarding water resources.

Stewardship is about supporting and maintaining the things we hold dear and about our ability to create valued legacy and heritage. Throughout development of the Strategy, Michiganders said they care deeply about the Great Lakes, about rivers and inland lakes, and about water in general. Stewardship is also about the ability of that care to persist over time within the state's communities and culture. It is one of the most important aspects of the Strategy, because it creates the backbone of our use and enjoyment of water in the state for generations.

Improve Water Literacy and Use of Place-Based Education

Michigan is blessed with abundant water resources, yet most citizens do not have a basic understanding of fundamental water literacy principles. During development of the Strategy, people across the state expressed the concern that many people do not know what a watershed is, or that they live in a watershed. As the Great Lakes state, Michigan should have water literacy principles as part of its K-12 curriculum standards.

Place-based education uses the elements of local community and environment as a starting point for teaching and learning, emphasizes hands-on, inquiry-based, real-world experiences, and, ideally, involves direct collaboration with community partners. This approach to education emphasizes the assets and context of the community and its place as part of a broader learning framework. The benefits of place-based education include powerful learning, a healthy, supportive school culture, sustainable partnerships between schools and communities a greater appreciation of the environment, and more frequent and effective acts of stewardship. Integrating freshwater systems into place-based educational experiences is critical to building literacy and stewardship for Michigan's water resources.

Recommendations

Integrate water literacy principles into place-based education and State of Michigan curriculum standards tied to Science, Technology, Engineering and Math (STEM) principles across all grade levels.

Develop a survey tool to assess behaviors and attitudes toward Michigan's water resources to assess changes over time.

Increase Volunteerism and Community Engagement

One of the key aspects of stewardship within a community is whether residents are willing and able to volunteer their time to better their water resources. Communities that exhibit strong stewardship characteristics have more individuals and groups engaged with the community and tend to support measures that drive good water management practices, such as environmental cleanups and funding programs. The focus on building stewardship and care can thus translate directly into long-term benefits to the community and the state and heighten engagement.

Recommendation

Expand opportunities to engage citizen volunteers and participation, such as the Michigan Clean Water Corp (MiCorps) program, in gathering water quality and quantity data, in restoration, in providing access and in maintenance of important water-related resources.

Table 2. Water Strategy Implementation Plan

Table 2 provides a five year implementation plan for the Water Strategy. It includes all 62 recommendations from the Water Strategy, an implementation metric for each recommendation and identifies a lead actor(s) responsible for initiating, convening, facilitating or implementing the recommendation.

Goal 1: Michigan's aquatic ecosystems are healthy and functional.			
Outcome: Aquatic ecosystems are resilient and diverse.			
#	Recommendation	Implementation Metric	Lead Actor
1	Prevent the introduction of new aquatic invasive species and control existing populations of aquatic invasive species in accordance with the Michigan Aquatic Invasive Species Management Plan.	By 2020, the ecological separation of the Great Lakes basin and the Mississippi River basin, especially in the Chicago Area Waterways system has been initiated.	State and federal agencies, Nongovernmental organizations (NGOs), local units of governments, individuals
2	Work with other Great Lakes states and provinces to harmonize aquatic invasive species prevention, early detection processes and response actions across the Great Lakes region.	By 2016, implement a pilot project with Ontario and interested states to evaluate and pursue areas of harmonization.	State agencies
3	Accelerate research and solutions to identify mechanisms of food web disruption and changes of nutrient flows in the Great Lakes with a focus on the effects of invasive species.	By 2017, a minimum of three new research projects will be established for the purposes of evaluating nutrient shifts in Great Lakes food webs to help focus appropriate management, social, and economic responses.	Universities
4	Develop a comprehensive strategy to prevent nuisance and harmful algal blooms.	By 2017, develop a strategy to prevent harmful algal blooms and HABs based on desired outcomes.	MDEQ, local public health departments
5	Achieve a 40% phosphorus reduction in the western Lake Erie basin.	Pending finalization and/or agreement with Annex 4 Water Quality Workgroup.	MDEQ, MDARD
6	Develop harmful algal toxin water quality criteria and implement a real-time monitoring strategy for Michigan's Great Lakes drinking water intakes and public recreation locations threatened by harmful algae.	By 2020, increase by 20% the number of people served by drinking water suppliers using surface water sources with real-time monitoring equipment installed to provide early warning of potential public health threats. By 2020, develop harmful algal toxin assessment criteria.	MDEQ

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		By 2020, implement a real-time monitoring strategy for Michigan's Great Lakes drinking water intakes and public recreation locations threatened by HABs.	
7	Support the development of a national drinking water advisory or action level target for harmful algal toxins.	Work with federal agencies to develop a national advisory target.	MDEQ
8	Incorporate planning for wet weather extremes and increased variability into state, regional and community planning.	Best management practices are reviewed every five years and updated (if necessary) to reflect climatic changes such as changes in rainfall frequency, duration or intensity.	State, regional governmental entities, communities
9	Provide technical assistance and develop technical tools and training programs for communities, local officials and water stakeholders to inform and improve their water literacy and help them integrate water impacts into local land-use planning and decisions.	By 2020, develop a public official water literacy measurement. By 2020, develop a training module for local elected officials and decision-makers on the connection between land-use planning and zoning and the siting and approval of new projects. By 2020, develop a training module for local elected officials and decision-makers on the merits and benefits of asset management planning.	Universities, regional government and planning organizations, MDEQ
10	Develop tools and guidance related to shoreline and riparian ecology and management and provide necessary technical support and training to municipalities, watershed-based organizations and landowners to achieve full benefits of riparian areas.	By 2020, develop a baseline for the current research and educational capacities. <ul style="list-style-type: none"> • Coordinate to pinpoint areas of capacity expansion. • Develop tools, guidance and training on best practices. • Determine need to update guidance and training materials. 	MDNR, MDEQ
11	Remove or improve dams that are no longer safe or ecologically, economically or socially viable to protect public safety and create healthy, connected aquatic systems.	By 2020, address all dams most at risk of failure.	MDEQ, MDNR
12	Focus river and stream restoration efforts on addressing small hydrological impediments like culverts to create connectivity and restore stream stability.	By 2020, increase the number of small hydrologic impediments that are restored over a baseline established in 2015.	NGOs and local units of governments

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13	Refine and improve the water withdrawal assessment process to ensure sustainable use of water resources and that high priority is given to incorporating existing and new data and models to better represent local and regional water resources and surface water/groundwater interactions.	By 2016, develop a list of priority Water Use Advisory Council recommendations and an implementation plan.	MDEQ, MDNR, MDARD
14	Provide technical and financial support to communities to plan and implement green infrastructure techniques and low-impact development while preserving natural spaces in the design of new developments, redevelopments and road projects to ensure storm water management and improve hydrology.	By 2020, increase the number of attendees to green infrastructure conferences, applications for projects, amount of grant dollars awarded to projects incorporating green infrastructure or low-impact development, and number of programs incentivizing green infrastructure projects and the number of Michigan communities that are recognized for green infrastructure projects and strategies over a baseline established in 2015.	MDEQ, MDOT, MDNR, Michigan State Housing Development Authority, MEDC
15	Modernize road and highway planning and infrastructure to effectively accommodate storm water runoff and infiltration needs, thereby reducing the costs and impacts of flooding.	By 2020, increase the number of Michigan's new road and highway projects designed to better accommodate storm water runoff and infiltration needs over a baseline established in 2015.	MDOT, local road and highway commissions
16	Enhance financial and technical support of local stakeholder efforts to develop and implement watershed management plans to restore impaired waters, protect high quality waters, and develop and utilize local water resource assets.	By 2018, increase the number of grants, training and educational opportunities on the development and implementation of watershed management plans over a baseline established in 2015.	MDEQ
17	Use existing authority to work with local units of government with storm water discharge or storm water-related hydrologic impairments in their waterways to establish Phase II storm water plans for impaired water bodies.	By 2020, increase the number of water bodies with storm water plans in place to address designated use impairments caused by storm water discharges and hydrologic impairments over a baseline established in 2015.	MDEQ, MDNR
18	Eliminate impairments in priority watersheds that have degraded water quality and/or aquatic ecosystems due to nutrient runoff and soil erosion. Engage	By 2018, identify priority watersheds. Develop performance standards to cover statewide land-use activities.	MDEQ, MDARD

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	landowners through a collaborative and adaptive community-based natural resource management process to identify local actions to change behaviors and solution to achieve those outcomes. Failure to achieve demonstrable outcomes within established timeframes could trigger additional measures.	<p>Agricultural land-use will directly follow MAEAP guidelines and participation criteria to remain consistent with the state's recent efforts. Concurrently develop the escalated "additional actions" triggered once a watershed has been determined to be impaired.</p> <p>By 2018, develop regional action teams with protocols for working with landowners. Educate collaborative teams on existing regulations and enforcement mechanisms allowed in their regions.</p> <p>By 2020, collaborative processes are in place with plans to achieve water quality outcomes in priority watersheds.</p>	
Goal 2: Michigan's water resources are clean and safe.			
Outcome: Surface and groundwater are managed to support sustainable human uses and ecological function.			
#	Recommendation	Implementation Metric	Lead Actor
1	<p>Protect drinking and source water areas by:</p> <ul style="list-style-type: none"> Continuing to ensure remediation activities address the long-term impact on drinking water sources Identifying and diligently protecting source water protection areas Assisting well owners with identifying potential water well vulnerabilities Focusing resources on contamination sources with the highest potential for causing contamination of drinking water supplies, including chemical storage facilities Enhancing the drinking water geographic information system database and making information available across MDEQ programs and to local public health department environmental health personnel Supporting mapping of local 	<p>By 2020, address IT security issues, such as firewall and server capacity, to make information publically available.</p> <p>By 2020, develop educational materials to encourage residents with private drinking water wells to test new wells prior to use for nitrates and arsenic and to test wells prior to sale or transfer for bacteria, nitrates and arsenic.</p> <p>By 2020, develop an interface to effectively and efficiently track and monitor for groundwater contamination, and implement data tracking.</p>	MDEQ, local health departments

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	groundwater conditions in partnership with well contractors and others who collect groundwater information.		
2	Develop a plan for aquifer protection that addresses geothermal construction and proper abandonment of wells.	By 2016, convene a stakeholder work group to develop draft legislation to regulate closed-loop geothermal construction. By 2020, develop educational materials for community water systems and local health departments to increase plugging rates of abandoned wells when municipal water mains are extended.	MDEQ
3	Establish inspection requirements for residential wells, including testing wells for nitrates, bacteria and arsenic.	By 2020, implement a statewide requirement for periodic inspections of drinking water quality.	Legislature
4	Develop a spill and communication strategy and organize an incident command approach to prevent, prepare for and respond to environmental disasters and chemical releases.	By 2016, implement the pipeline strategy currently being developed under the leadership of MDEQ and the Attorney General.	MDEQ, MDNR, MDARD, Michigan State Police, Department of Technology, Management and Budget
5	Develop and implement a uniform statewide sanitary code that is flexible and provides standards for site suitability based on risk. Establish a long-term, sustainable funding source to support onsite wastewater programs at the state and local levels and to assist financially distressed owners of private on-site wastewater systems with repair and replacement costs.	By 2020, every county health department has an inventory and assessment of private, single-family home water supplies and all septic systems. By 2020, secure a long-term funding source to complete the inventory and to assist distressed owners.	Legislature
6	Establish inspection requirements for residential on-site wastewater systems.	By 2020, implement a statewide requirement for periodic inspections of on-site septic system performance for properties with on-site wastewater systems.	Legislature
7	Develop marketing and education campaigns and outreach tools directed at homeowners' on-site wastewater management and maintenance and funding opportunities to assist with repair and replacement.	By 2020, increase the number of entities implementing outreach campaigns directed at homeowners on septic management.	NGOs, local units of government,

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8	Secure a long-term funding source to accelerate the cleanup of legacy contaminated sites.	By 2027, close and remove 7,500 sites from the 201 Facilities Inventory, National Priority List, Leaking Underground Storage Tank Site database and designated Areas of Concern.	Legislature
9	Pass comprehensive legislation phasing out the use and sale of microbeads in Michigan.	By 2017, comprehensive legislation phasing out the use and sale of microbeads is signed into law.	Legislature
10	Establish research priorities for “emerging pollutants of concern” in partnership with Michigan’s research universities to: <ul style="list-style-type: none"> • Better understand potential ecological and human health impacts • Adapt monitoring protocols to detect concentrations, fate and transport • Recommend standards for protection of human health and the environment • Develop technologies to remove such pollutants from manufacturing processes 	By 2016, increase the number of evaluations and risk assessments completed, new standards developed, and monitoring protocols developed.	MDEQ, Michigan Department of Community Health

Goal 3: Michigan communities use water as a strategic asset for community and economic development.

Outcome: Economic and community development plans and efforts fully leverage water assets to create great places to live, work and play.

#	Recommendation	Implementation Metric	Lead Actor
1	Emphasize water resources as assets in state, regional and community planning efforts to provide appropriate, sustainable protection and to fully leverage community-based economic opportunities.	Increase walkability score of waterfront communities to measure the effect of economic activity and investment on or near water in a community, watershed or region.	MSDHA, MEDC, MDEQ, MDNR regional governments, local units of government
2	Host an annual mayor’s summit focused on creating high-quality communities that leverage strategic water assets.	Increase in property values as a result of increased economic activity and investment on or near water in a community, watershed or region.	Mayors
3	Provide in-depth technical assistance to support communities with developing and implementing community visions and strategies for waterfront redevelopment, access and use.	Increase in the number of communities participating in Redevelopment Ready Communities Program.	Regional and interagency teams

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4	Prioritize investments around strategic economic assets of commercial harbors and long-term, sustainable infrastructure.	By 2020, increase the percentage of commercial traffic and other economic activity at Michigan's commercial ports over a baseline established in 2015.	MDOT, MDNR, MDEQ's Office of the Great Lakes, Governor's Office of Public-Private Partnerships, commercial maritime interests, local planning professionals
Goal 4: Michigan's water resources support quality recreation and cultural opportunities.			
Outcome: Waters of the state are world renowned for recreational pursuits such as hunting, fishing, boating and swimming.			
#	Recommendation	Implementation Metric	Lead Actor
1	Expand the use of real-time monitoring and source tracking techniques at high risk beaches by local health departments, counties, communities and universities, and address sources of beach contamination.	By 2020, all of Michigan's water meets total and partial body contact designated uses with no closures or advisories. Real time monitoring at all high-risk beaches.	MDEQ, local health departments, local units of government, universities
2	Continue national and regional coordination of mercury reduction activities, such as implementation of the Great Lakes Mercury in Products Phase-Down Strategy and the Great Lakes Mercury Emission Reduction Strategy.	Reduce the mercury levels in edible portions of Great Lakes, inland lakes and stream fish to below 0.35 parts per million by 2020.	MDEQ, MDCH
3	Prioritize infrastructure needs for repair and upgrade of public recreational harbors and their landside access.	By 2020, increase the number of recreational harbors with asset management plans over a baseline established in 2015.	MDNR, Waterways Commission, MDEQ, MDOT
4	Establish a harbor town program and improve marketing of harbors. The program should work with MDEQ to address sources of upstream sediment, sediment reduction and relocation strategies.	By 2017, establish a harbor town program.	MDNR
5	Work with local partners to provide public access every five miles on the Great Lakes, on all priority lakes over 100 acres in size and on every five miles of navigable water, as environmentally appropriate.	Public access every five miles on the Great Lakes and on all priority inland lakes larger than 100 acres.	MDNR
6	Work with stakeholders to develop and implement a designated water trail system for inland waterways and along the coast.	By 2020, a designated a water trail system has been established by the MDNR.	MDNR, local units of governments, , NGOs

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Goal 5: Michigan has a strategic focus on water technology and innovation to grow sustainable water-based economies.			
Outcome: Policies and innovative technologies are developed and adopted to grow and promote sustainable water-based economies.			
#	Recommendation	Implementation Metric	Lead Actor
1	Market the state's competitive advantage as a highly attractive place for business creation and investment because of our abundant natural water assets, water research capabilities, highly skilled talent, economic development expertise, and powerful tourism and business-marketing brand.	Increase the number of water-dependent companies and investments locating in Michigan. Specifically track aquaculture technology and related opportunities.	MEDC
2	Establish voluntary water efficiency targets for all major water sectors to reduce water use impacts and costs.	By 2020, develop a baseline for water usage, data collection and definitions to inform development of water conservation goals and objectives. Collect data for two years. Increase by 20% the number of businesses, industries, and municipalities with water efficiency within their water management plans.	Water use sectors
3	Promote innovative technologies that reduce cost and water loss, or convert waste products to usable materials.	By 2020, increase the number of new, innovative and cost-effective technologies, pilot projects, and startups are commercialized, come to market and result in connections with end users to reduce costs and water consumption, or convert waste products to usable materials and produce energy over a baseline established in 2015.	MDEQ, MDARD, MEDC
4	Develop a water conservation and reuse strategy for the state that incorporates the use of green infrastructure, grey water systems, and energy production that includes recognition programs.	By 2018, develop a water conservation and reuse strategy that identifies major sectors by water use and their locations.	MDEQ, MDARD, MDOT
5	Fund a pilot project, through a competitive bid process, for the initiation and evaluation of a new model for wastewater management. This pilot program will assess the opportunities and barriers to creating a "Water Resources Utility of the Future," focused on:	By 2017, pilot project is funded.	Legislature

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	<ul style="list-style-type: none"> Reclaiming and reusing water Extracting and finding commercial uses for nutrients and other constituents Capturing waste heat and latent energy in biosolids and liquid streams Generating renewable energy using its land and other assets Using green infrastructure to manage storm water and improve urban quality of life 		
6	Establish voluntary water efficiency targets for agriculture in areas of existing or potential water stress.	By 2017, develop a baseline for water usage, data collection and definitions to inform development of water conservation goals and objectives in areas of existing or potential water stress. Collect data for two years. Establish targets. Increase in the number of water stressed regions that have water efficiency plans and water efficiency targets by 2020.	MDARD
7	Create a strategic focus on water innovation to attract and accelerate new technologies to market through a business-led council comprised of private investors, entrepreneurs, corporations, public agencies and universities to better manage water challenges in Michigan and worldwide.	By 2020, increase the number of new, innovative and cost effective technologies, pilot projects, and startups that are commercialized, come to market and result in connections with end users to solve water problems over a baseline established in 2015.	MDEQ, MEDC, MDNR, MDARD
Goal 6: Michigan invests in infrastructure and supports funding to maintain clean water and healthy aquatic ecosystems.			
Outcome: People support investment of both public and private funding of Michigan water resources.			
#	Recommendation	Implementation Metric	Lead Actor
1	Implement a communication strategy focused on messages that link the relationship between investments in water infrastructure and clean water and the benefits infrastructure provides for drinking water, recreation, and cultural and economic opportunity.	By 2017, implement a communication strategy focused on connecting economic, environmental, social and cultural values to Water Strategy outcomes.	NGOs, MDEQ, MDCH

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2	Utilize pricing and funding strategies to support infrastructure improvements while allowing for water conservation.	By 2020, increase the number of communities that have pricing and funding strategies as part of their asset management plans to support infrastructure improvements over a baseline established in 2015.	Local units of government, water utilities
3	Evaluate current community practices regarding providing water to financially distressed customers to ensure all citizens have affordable access to water for drinking and sanitation.	By 2017, increase the number of communities that have practices in place to ensure financially distressed customers have access to water for drinking and sanitation over a baseline established in 2015.	Local units of government, water utilities
4	Incentivize and require outcome-based asset management planning for all public water utilities that includes more efficient use of resources.	By 2020, require all major NPDES-permitted dischargers to develop and implement asset management planning for each system. By 2020, require all municipal community water suppliers serving more than 1,000 people to develop and implement asset management planning for each system.	MDEQ
5	Establish sustainable funding mechanisms to achieve the Water Strategy goals including water infrastructure management.	By 2020, implement a long-term funding strategy to achieve goals of the Water Strategy and support existing Quality of Life Agency programs and policies.	State agencies, Legislature
6	Develop an “enterprise budget” in order to better understand the complex relationships between managing water, infrastructure needs and funding	By 2016, develop an enterprise budget for water to inform the long-term funding strategy.	MDEQ

Goal 7: Michigan has integrated outcome-based monitoring systems that support critical water-based decisions.

Outcome: Monitoring systems are in place at a scale and frequency to ensure water quality and quantity are maintained to support diverse uses and values.

#	Recommendation	Implementation Metric	Lead Actor
1	Implement a pilot decision support framework that includes monitoring; data and information; and analytical tools for assessing ecological, economic, social and cultural values and outcomes at local and regional watershed scales.	By 2017, fund and implement a water resource decision support framework that provides information about the integration of ecological, economic, social and cultural values and outcomes.	MDEQ, MDNR, MDCH, MDARD

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2	Develop a coordinated, comprehensive monitoring strategy for groundwater quantity and quality, including a data management system.	By 2018, implement a long-term groundwater monitoring strategy that provides information sufficient to assess status and trends in quality and predict impacts from groundwater withdrawal.	MDEQ
3	Develop a long-term, sustainable funding source for groundwater and surface water quality and quantity monitoring that is continually improved with new technologies.	By 2018, fund and implement surface water and groundwater monitoring strategies that provide information sufficient to assess water quality and quantity status and trends, and detect emerging issues.	Legislature

Goal 8: Michigan has the governance tools to address water challenges and provide clean water and healthy aquatic ecosystems.

Outcome: Policies, organizational and institutional structures are in place to achieve goals and outcomes of the Strategy.

#	Recommendation	Implementation Metric	Lead Actor
1	Enhance the understanding, knowledge and skill set of communities to facilitate and support community-based dialogue and water-related vision development.	By 2016, work with community foundations and private foundations to support community-based dialogues.	Community and private foundations
2	Create a statewide Water Fellows Program and Network to build community leadership and inform critical local leaders about how to leverage water resource assets to build community and economic vitality.	By 2016, establish and implement a Water Fellows Program.	Private philanthropy
3	Evaluate and implement necessary changes to laws including state and local land-use statutes as well as the Michigan Drain Code to create a more integrated, watershed based system for managing water at the landscape level and achieving water quantity and quality outcomes.	By 2016, create an ad hoc external advisory body to evaluate existing laws and statutes including the Drain Code and local land-use statutes. By 2018, panel should provide recommendations to the Directors.	MDEQ and MDARD Directors
4	Retain full authority under the Clean Water Act to continue to manage Michigan's own water resources.	Continue assumption of federal programs under the Clean Water Act.	MDEQ
5	Create an Interdepartmental Water Team to unite agencies to ensure a cohesive common strategy around implementation of the Water Strategy. The team will establish a process for stakeholder collaboration, criteria for setting implementation priorities, identifying cross agency joint	By 2015, create interdepartmental water team. By 2015, put a working agreement in place to establish implementation priorities, a process for stakeholder collaboration, and an adaptive	MDEQ, MDNR, MDARD and MEDC Directors

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	projects and an approach to assess and evaluate progress achieved against the metrics and outcomes.	management approach to evaluate progress achieved against metrics and outcomes.	
Goal 9: Michigan citizens are stewards of clean water and healthy aquatic ecosystems.			
Outcome: Individuals and communities understand their responsibility for and make informed and responsible decisions regarding water resources.			
#	Recommendation	Implementation Metric	Lead Actor
1	Integrate water literacy principles into place-based education and state of Michigan curriculum standards tied to Science, Technology, Engineering and Math (STEM) across all grade levels.	By 2016, develop a strategy to integrate freshwater literacy principles into place-based education and state curriculum standards.	MDEQ, MDNR and Department of Education, State Board of Education
2	Develop a survey tool to assess behaviors and attitudes toward Michigan's water resources to assess changes over time.	By 2016, develop a Gant chart that encompasses all implementation activity timelines. Develop clear metrics about stewardship related to: <ul style="list-style-type: none"> • Ability to fund water quality infrastructure • Measuring the community's connection to local water assets • Knowledge of, and affinity for, local waters • Metrics of volunteerism and local philanthropy that support a community's vision for water and water-related assets • Measuring actual progress versus planned 	MDEQ, MDNR, Universities
3	Expand opportunities to engage citizen volunteers and participation, such as the Michigan Clean Water Corp (MI Corps) program, in gathering water quality and quantity data, in restoration, providing access and maintenance of important water-related resources.	By 2016, develop a list of participants and define engagement levels. Track progress toward increasing engagement levels.	MDEQ, MDNR

Table 3: Other Recommendations Identified During the Development Process

Goal 1: Michigan's aquatic ecosystems are healthy and functional.		
Outcome: Aquatic ecosystems are resilient and diverse.		
#	Recommendation	Lead Actor
1	Conduct research to assess natural and social systems that comprise Michigan's Great Lakes shorelands. Include patterns of shoreline development, coastal wetland habitats, beach structures, local revenues generated from shoreland development, and use and costs incurred from development. Determine the taxpayer (public) versus insurance (private) burden of coastal damage and flooding scenarios.	Universities
2	Develop a detailed toolbox of options to provide long-term funding for storm water management, including providing support for the creation of storm water utilities.	Michigan Municipal League
3	Develop a database and conduct a statewide inventory of county and inter-county drains as well as public road and highway-dedicated drainage, including maintenance intervals and associated costs.	MDARD, drain commissioners, county road agencies, MDOT, MDEQ
4	Enhance the efforts initiated by the state parks system to incorporate green infrastructure within design and operations plans for state-owned properties like parks, roadways, prisons and schools.	DTMB
5	Develop the "Healthy Waters, Working Farms: For Future Generation Initiative," a pilot public-private partnership and locally led effort to protect farmland and address water quality, farmland preservation, and fish and wildlife habitat through a system of permanent easements and a network of conservation practices on private working lands in areas with high-priority water quality concerns.	MDEQ, MDARD, NGOs
Goal 2: Michigan's water resources are clean and safe.		
Outcome: Surface and groundwater are managed to support sustainable human uses and ecological function.		
#	Recommendation	Lead Actor
1	Promote USDA rural development funding to high-priority areas with high rates of septic system failure to replace or to maintain old septic systems or provide resources to connect to public wastewater treatment systems, if available.	MDARD
2	Establish a non-federal funding mechanism to leverage federal Great Lakes Legacy Act funds to continue the remediation of contaminated sediments in Areas of Concern by 2018.	Legislature
3	Provide water supply intake locations and information to environmental response companies upon request, and notify communities and drinking water plants that may be impacted by spills.	Legislature, MDEQ

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4	Require decentralized wastewater treatment systems be included in planning for state funding of wastewater infrastructure improvements and extensions.	MDEQ, Legislature
Goal 3: Michigan communities use water as a strategic asset for community and economic development.		
Outcome: Economic and community development plans and efforts fully leverage water assets to create great places to live, work and play.		
#	Recommendation	Lead Actor
1	Ensure common water resources and adjacent land resources are managed in harmonious ways in communities and regions through coordination and collaboration to protect water resources while facilitating waterway-appropriate public use, commercial and amenity development, and recreation.	Local units of government, Regional governmental entities
Goal 4: Michigan communities use water as a strategic asset for community and economic development.		
Outcome: Waters of the state are world renowned for recreational pursuits such as hunting, fishing, boating and swimming.		
#	Recommendation	Lead Actor
1	Implement recommendations developed in partnership with Michigan Sea Grant, National Weather Service, the Great Lakes Research Center at Michigan Technological University and others to improve information for beachgoers on wave conditions and dangerous near-shore currents. Information should be available and accessible at beaches through a variety of media, including smart devices.	MDNR, MDEQ, local units of government
2	Complete the state's harbor of refuge system.	MDNR
3	Invest in innovative and technological advancements to lower the cost and frequency of dredging.	U.S. Army Corp of Engineers
Goal 5: Michigan has a strategic focus on water technology and innovation to grow sustainable water-based economies.		
Outcome: Policies and innovative technologies are developed and adopted to grow and promote sustainable water-based economies.		
#	Recommendation	Lead Actor
1	Researchers should seek funding to extend research and quantification of the risk profile water plays in corporate profitability and performance volatility. Differentiate the state and the Great Lakes from other regions of the country for financial managers and investors.	Universities
2	Expand the University Research Corridor's inventory of Michigan's water-related industries to include other water-related sectors, such as tourism and recreation, and conduct an inventory of water research projects at Michigan universities to further define and identify the scope of Michigan's water sector.	Universities

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3	Direct funding of studies conducted through the Agriculture Partnership Wastewater Workgroup to develop new technologies and best management practices to address tile lines and water management, and pilot and evaluate the adoption of innovative methods for nutrient management from tile line discharges. Existing institutional structures should be used to connect end users with technologies to ensure implementation of effective water management techniques and technologies.	MDARD
4	Create a coordinated public-private program of education and incentives to promote efficient use and conservation of water.	MDEQ, MDCH
5	Collaborate with the National Science Foundation International to set a framework for gray water and water reuse applications to protect public health and minimize risk. Modify applicable building and plumbing codes to allow for the adoption of water reuse strategies.	MDEQ, MDARD, MDCH
6	<p>Use all available tools and create new ones, including existing and new funding opportunities, to attract technology providers to address specific water quality and quantity issues, and develop strategies to connect end users with technologies. Incentivize and invest in areas including but not limited to:</p> <ul style="list-style-type: none"> • Increasing technology innovation capacity in the application of rapid response E. coli testing for surface waters • Developing a market to attract innovative technology developers for low-cost, environmentally sound sediment remediation, sediment removal, reuse and disposal • Developing low-cost methods of remediating pollutants that falls outside of traditional regulatory system • Researching treatment technologies to prevent introduction and spread of invasive species by ballast water • Developing technology to address special challenges facing food processors • Developing technology to address water issues associated with fracking • Developing technology to further improve green infrastructure design and maximize infiltration capacity and/or water retention • Increasing technology innovation capacity in treatment technologies to reduce phosphorus loading from municipal systems • Developing efficient technologies to remove and separate nitrogen and phosphorus through permeable membranes for use in anaerobic digestion • Increasing technology and innovation that addresses the intersection of energy, water and food systems • Increasing energy efficiency and water quality recirculation systems for aquaculture and aquaponics for urban, closed-cycle food production systems • Developing technologies to enable higher efficiency water delivery systems and water conservation, including work on advanced drain tile management systems 	MDEQ, MEDC, MDARD, MDNR

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Goal 7: Michigan invests in infrastructure and supports funding to maintain clean water and healthy aquatic ecosystems.

Outcome: People support investment of both public and private funding of Michigan water resources.

#	Recommendation	Lead Actor
1	Continue to advocate for Great Lakes Restoration Initiative funding and other federal programs that support the Great Lakes.	State agencies, NGOs, Local units of government

Goal 9: Michigan citizens are stewards of clean water and healthy aquatic ecosystems.

Outcome: Individuals and communities understand their responsibility for and make informed and responsible decisions regarding resources.

#	Recommendation	Lead Actor
1	Coordinate, deliver and support ongoing freshwater-focused professional development for Michigan's K-12 educators. Convene statewide summer seminars for Michigan K-12 educators where best practices in teaching core environmental education concepts can be refined and shared.	Nonprofit organizations

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